SCIENTIFIC REPORTS

OF

THE INDIAN AGRICULTURAL RESEARCH INSTITUTE

For the Year Ending 30th June 1956

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PART I—REPORT OF THE DIRECTOR

1.(*a*) Introductory

One of the new research activities of the Institute deserving special mention at the outset is the use of radio-active isotopes in agricultural research. The work was initiated under an Indo-U. S. Agreement, in the Division of Soil Science and Agricultural Chemistry, to study phosphorus deficiencies of Indian soils, and later on studies on placement of superphosphate and available phosphorus in the soils were also taken up. The work with radio-active isotopes expanded in scope and by the close of the year under report radio-active isotopes were being used for inducing mutations in crop plants, for studying the effect of atomic radiations on fungi and for investigating certain entomological problems and the main lines of studies so far made have been promising and are likely to open up a vista of potentialities of no mean value to the cause of Indian agriculture.

Steady progress was maintained on the large number of research projects and programmes. Out of the large number of new schemes proposed under the Second Five Year Plan, it was found possible to advance the implementation of a substantial number of them with the result that the volume of work increased considerably. The admission for post-graduate education continued to increase and as a result of adding an additional block to the hostel it was possible to make an increased number of admissions.

On April 12, 1956, a "Memorandum of Understanding" was signed between the Government of India and the Rockefeller Foundation. Under this Memorandum the Rockefeller Foundation agreed to collaborate with the Government of India towards :

(i) Establishment of a post-graduate school as a wing of the Indian Agricultural Research Institute, and

(ii) An active programme directed towards cereal improvement in India with particular emphasis on hybrid maize, sorghum and millets.

This is regarded as a matter of great potential significance for the future development of the Institute.

(*b*) Leave, Transfer and Posting of Gazetted Staff

Directorate

Dr. B. P. Pal continued to be Director of the Institute during the period under report except for 60 days from 7th November, 1955 to 5th January, 1956 when he proceeded on leave and Dr. R. S. Vasudeva, Assistant Director, officiated as Director.

Dr. R. S. Vasudeva, Head of the Division of Mycology, took over charge of the office of the Assistant Director with effect from 7th September, 1955.

Division of Agronomy

Dr. T. J. Mirchandani, Head of the Division of Agronomy and Principal, Central College of Agriculture, was placed on foreign service with the Damodar Valley Corporation from 30th July, 1955. Dr. P. C. Raheja, Agronomist, was appointed

the post of Head of the Division of Agronomy with effect from the same date ·i J. J. Chandnani, Assistant Agronomist, was appointed to the post of Agronomist the Scheme for Irrigation Investigation, on 19th November, 1955. On return m leave out of India, Dr. R. D. Verma, Assistant Agronomist, was appointed as ronomist in the Scheme for Investigation on Weed Control from 23rd February 56.

·ision of Botany

Dr. D. Chatterjee, Systematic Botanist, was relieved on the afternoon of 25th y, 1955, to join the post of Superintendent, Botanical Gardens, Sibpur, Calcutta. ·i Harbhajan Singh, Assistant Geneticist, was appointed as Vegetable Specialist, getable Breeding Sub-station, Katrain, on 26th November, 1955. Dr. P. N. adui, Cytogeneticist, was relieved on 5th April, 1956, to take over the post of ad of the Department of Botany, Presidency College, Calcutta. Dr. M. S. Swamihan, Assistant Cytogeneticist, was appointed to the post of Cytogeneticist with ct from the same date.

·ision of Chemistry

Dr. R. V. Tamhane, Soil Survey Officer, was appointed as Special Officer in the eme for Expanded Soil Testing Service from 27th July, 1955. Dr. K. V. S. yanarayana, Assistant Soil Survey Officer, was appointed to the post of Soil vey Officer on 23rd February, 1956. Dr. K. C. Gulati, who was on other duty he Ministry of Commerce and Industries, resumed charge of the office of Organic mist on 1st September, 1955. Dr. S. V. Govindarajan was appointed as Soil relator in the All India Soil Survey Scheme at the Bangalore Centre from 3rd ruary, 1956.

ision of Entomology

Dr. E. S. Narayanan, Head of the Division of Entomology was placed on deputa- for advanced training in biological control of insect pests in the U. S. A. for the od from 6th April to 6th September, 1955.

Dr. M. G. Ramdas Menon was appointed to the post of Systematic Entomo- st on 24th March, 1956. Dr. Rattan Lal was appointed as Insect Physiologist he Scheme for Research on Insect Physiology on 8th December, 1955.

sion of Mycology

Under an assignment with the Food and Agriculture Organization of the United ons, Dr. R. S. Vasudeva, Head of the Division of Mycology, was placed on de- tion and proceeded to the Philippines for the period from 2nd May, 1955 to July, 1955. Dr. M. K. Hingorani, Assistant Plant Bacteriologist, was inted as Plant Bacteriologist in the Scheme for the Study of Bacterial Plant logens from 17th November, 1955.

'sion of Agricultural Engineering

Shri C. Vedantiah was appointed as Technical Officer in the Scheme for Tractor ing Station from 14th June, 1956 but was relieved on the afternoon of 21st ember, 1956, as the administrative control of the Tractor Testing Station was sferred to the Central Tractor Organization.

Central College of Agriculture

On the deputation of Dr. T. J. Mirchandani to the Damodar Valley Corporation, Dr. R. S. Vasudeva was appointed as Principal, Central College of Agriculture from 30th July, 1955 and he continued in this post upto 6th September, 1955. Dr E. S. Narayanan, Head of the Division of Entomology, took over charge as Principa from Dr. R. S. Vasudeva on the 7th September, 1955.

(*c*) ACCOUNTS DURING 1955-56

The total expenditure of the Institute and its sub-stations at Karnal and Pusa during the financial year ending 31st March, 1956, amounted to Rs. 32,24,199 as under :

I—	(i) General expenditure on the Institute including the office of the Director, irrigation, power supply, gas plant, estate establishment, Indian Agricultural Research Institute Dispensary, etc. . . .		6,54,074
	(ii) Agronomy (including Sections of Statistics and Economics)		4,36,369
	(iii) Botany		5,74,024
	(iv) Soil Science and Agricultural Chemistry . .		5,34,998
	(v) Entomology		2,24,530
	(vi) Mycology and Plant Pathology		2,38,362
	(vii) Agricultural Engineering		1,76,592
	(viii) Central College of Agriculture		1,81,407
		TOTAL .	30,20,356
II—*Experimental Farms*			
	(i) Agricultural Sub-station, Karnal . . .		1,21,783
	(ii) Botanical Sub-station, Pusa		82,060
		TOTAL .	2,03,843
	GRAND TOTAL OF I AND II . . .		32,24,199

2. SUMMARY OF MAIN RESULTS OF RESEARCH (1955-56)

AGRONOMY

The research programme of the main Division of Agronomy, as well as of the Agricultural Research Sub-station at Karnal, was revised on the lines suggested by the Expert Committee set up by the Ministry of Food and Agriculture. The experimental results are reported under the reorganised sections.

(*a*) *Soil Fertility.* In the experiments on manuring and fertilisation of crops in rotations, for the maintenance of soil fertility, the residual response of green manuring with *guar* (*Cyamopsis tetragonoloba*) was found to be not appreciable even in the third cycle of the series in the rotation : *guar*-wheat-maize-wheat. Green manuring of wheat proved more economical than double cropping of land with the rotations : maize-wheat : maize-peas ; and cowpeas-wheat.

The yields of maize and wheat in the restorative rotation, which included peas in alternate years, were not higher than in the exhaustive rotation, wheat-maize, in spite of the former type of rotation being fertilised with top dressing of N, P and K. It was also found that the exhaustive rotation, wheat-*bajra*, cannot be successfully practised under irrigation despite heavy manuring. Fallowing appreciably restores fertility.

The direct and residual effects of phosphate applied to berseem, succeeding maize, proved very remunerative.

In a sixteen-rotations experiment, outturn of potato in the rotation, G. M.-wheat-fallow-potato-sugarcane, was higher than in G. M.-potato-maize-peas.

In paddy and wheat, fertilisation with 20 lb. and 40 lb. N in the form of ammonium sulphate, ammonium nitrate and urea, did not augment yield. The ratio of response to nutrients in Farm Yard Manure, as compared with that obtained from artificial fertiliser nitrogen was 1 : 2 in paddy and 1 : 3 in wheat.

Application of nitrogen to wheat, in two split-up doses, resulted in higher yields than the full dose applied at sowing time.

Fertiliser experiments with wheat and paddy, using 15 and 30 lb. levels of P_2O_5 from superphosphate, nitrophosphate and ammonium phosphate did not bring about differences in yield, nor did their broadcasting or placement below seed.

In N, P, K experiments, the interaction NP was significant in wheat, but not in the case of paddy.

(*b*) *Field Crops.* In varietal trials, the wheat varieties, N. P. 770, N. P. 111 and N. P. 775 were the top performers. At Karnal, Punjab C. 591 and N. P. 792 gave the best yields under conditions of severe drought. The rust resistant linseed strains, N. P. (R. R.) 45 and N. P. (R. R.) 9, and the paddy strains-C. H. 45 (medium-coarse), N. P. 130 (medium-fine) and N. P. 137 (fine) gave the topmost yields.

The response to graded doses of nitrogen was the best in N. P. 718 and N. P. 720 among the wheat varieties tested and in the paddy strains, N. P. 130 and N. P.97, which gave response superior to that given by the local, *Jhona.*

In tillage experiments, it was confirmed that in maize and pigeon pea deep ploughing with tractor does not produce better yields than shallow ploughing with bullocks.

The sesamum strain, S, evolved at this Institute as a result of interspecific hybridisation, gave the best yield over fourteen other strains collected from all parts of India.

In agronomic experiments with forage grasses, Elodes grass and Blue Panic gave high linear response to nitrogen: cutting at 30-day intervals was found to be optimum for these grasses. Under irrigation, outstanding performances were given by *Setaria sphacelata*, *Brachiaria brizantha*, and *Urochloa moserbicensis*. *Digitaria eriantha*, among grasses, and *Phaseolus lathyroides* among the legumes, showed the highest protein content.

(*c*) *Vegetables and Commercial Crops.* In fertiliser experiments with tomato, 90 lb. N +60 lb. P_2O_5 produced 71·3 mds. of extra fruit per acre over 447·4 mds. given by the control plot (10 tons Farm Yard Manure). In cauliflower, while phosphate appreciably increased yield, molybdenum had little effect.

The plant, and ratoon-cane, varieties of sugarcane, *viz.*, Co. 998 and Co. 957, gave good performances; they were sent out to some Delhi villages for testing in cultivators' fields.

For *hookah* tobacco (*Nicotiana rustica*), 40 lb. N+80 lb. P_2O_5 appears to be the optimum fertiliser treatment. In potato, the highest response was given by 160 lb. N+80 lb. P_2O_5 +40 lb. K_2O.

(*d*) *Farm and Cattle.* The Section was reorganised with a view to reducing costs and increasing receipts.

The Sahiwal herd maintained its high levels of wet (23·5 lb.) and over-all average (15·5 lb.). Two cows gave more than 9,000 lb. of milk yield per lactation and three, over 8,000 lb.

(*e*) *Fertiliser-use Project.* The second report on fertiliser trials with wheat (22 centres) and the third report on paddy (21 centres) were compiled. During 1954-55, 895 experiments were conducted on wheat at the Community Project Centres and 55 at the Complex Trials Centres. With 20 lb. and 40 lb. N, the responses were 2·56 and 4·87 mds., respectively; with similar phosphate doses, the extra outturns were 2·36 and 3·58 mds., respectively, per acre. In a total of 848 similar experiments carried out on paddy, during 1955-56, the average responses to 20 lb. and 40 lb. levels of N were 3·66 and 6·00 mds., respectively; for corresponding levels of phosphate, the responses were 1·89 and 3·05 mds., respectively. The nitrogen response was noticeable on 20 soil types, while two-thirds the number of soil types responded to phosphate.

(*f*) *Irrigation Investigation Scheme* (Second Five-Year Plan). A new series of irrigation experiments was initiated for determining crop patterns, in relation to intensity, frequency and depth of irrigation, as also on the economics of spray irrigation.

In wheat, three irrigations with 40 lb. N gave the highest outturn. Frequent shallow irrigations in potato resulted in greater tuber yield than less-frequent, but deeper, irrigation. In spray irrigations at 0·75 and 1·0 acre-inch, the moisture penetrated only the first twelve inches of the soil, while it seeped beyond one foot when sprayed at 1·25 acre-inch level.

(*g*) *Weed Control Investigations* (Second Five-Year Plan). A series of experiments was started to study the selectiveness, post and pre-emergence effects and residual effects of weedicides, as also to assess them as partial or complete substitutes for mechanical intercultivation in the field.

Post-emergence spraying with 2, 4-D appreciably suppressed the growth of weeds in the wheat and pea crops; in the latter crop, pre-emergence application of trichloro-acetic acid was ineffective.

(*h*) *Agricultural Extension Project* (Second Five-Year Plan). Eight students were admitted to the newly-organised post-graduate course in agricultural extension.

Under the Intensive Cultivation Scheme of the Institute operating in Delhi villages, 777 demonstrations were carried out. The wheat variety, N. P. 718, saturated an area of 2,099 acres. For the production of pure seed of improved varieties, 469 acres under the various crops were rogued. Green manure crop was raised on 49 plots, and 250 fertiliser demonstrations were conducted. Three key-village centres, for servicing *Hariana* cattle and *Murrah* buffaloes, were set up and castration of scrub bulls was commenced in 19 villages. Stock breeders in this area were given advice on feeding of cattle and treatment of diseased cattle.

Seed Distribution. 2,028 mds. of seed of improved varieties was produced for distribution. In addition, 1,728 mds. of sugarcane setts, 429 seed samples of grasses and legumes, and 1,500 crowns of the kudzu vine were supplied to indentors.

AGRICULTURAL ENGINEERING

(*a*) *Bullock-drawn machine for fertiliser placement.* A proto-type, single-row, bullock drawn machine has been built for placing fertiliser as well as for sowing. The rates of both these operations can be adjusted on the machine, in which the seed mechanism is at present designed only for cereal crops.

(*b*) *Harness for a single bullock for field work.* In India, a pair of bullocks is invariably used in farm work, while in some east-Asian countries farm implements are hitched on to a single bullock or buffalo. A proto-type harness has therefore been built. It is so designed that the bullock exerts the draft from both sides of the breast, and not from the neck as in the case of the present yoke-harnessing. Further work is in progress to improve the hitching arrangement. Field tests have indicated that bullocks, which are used to working in pairs, have to be trained for single work.

(*c*) *Mechanical seed dibbler.* Several laboratory models have been designed for developing a suitable, hand operated, semi-automatic seed dibbler, which would simultaneously mark the points of dibbling and dibble the seeds as required. Tests on these models are under way.

(*d*) *Improvements in indigenous implements.* By providing a suitable clutch mechanism to a type of automatic seed drill, at present in use in the Punjab, it has been possible to fully control its seed-dropping arrangement.

For increasing the output and efficiency of a circular-type water-lifting *mhote*, used in Madras, a drum has been designed and integrally mounted on the axle. Efficiency and relative-performance tests are in progress.

BOTANY

A. Plant Breeding and Genetics

(i) *Breeding disease resistant wheat varieties.* This work has been in progress at Delhi and at the substations at Pusa, Simla, Indore, and Wellington; another station was established during this year at Bhowali (U. P.) for this work.

Extensive progenies of crosses, made for combining genes for rust resistance from diverse sources with desirable agronomic characters, including lodging resistance, were thoroughly tested and screened and a number of promising selections have been made. Many of these selections are resistant to loose smut also. The work of selecting varieties giving high response under different agronomic conditions has yielded some very useful results. Three new rust resistant strains *viz.*, HD.52-66, HD.53-35, and HD.52-46, can be termed as all-purpose wheats; they are suitable for early and late sowing, for irrigated and unirrigated land and they have also shown remarkable standing power and excellent response under high-fertility conditions. At Indore, some very good rust resistant hybrid derivatives have been selected in *Triticum durum*, and at Wellington a rust resistant selection in *T. dicoccum* has given promising yields. Of the foreign introductions tested in the field under artificial rust inoculation, four—namely, Yaqui 53 and Bonic from the U. S. A., Tremez Molle from Portugal, and Kenya Ploughman from Kenya, were free from all the rusts. They, thus, constitute useful breeding material.

The four newly-evolved rust and smut resistant strains, N. P. 792, N. P. 797, N. P. 798, and N. P. 799, have given gratifying performances in several trials conducted in the principal wheat-growing tracts. N. P. 797 has done very well in Bombay State and Orissa, and N. P. 798 in Saurashtra.

Among the older wheats of the N. P. 700-series, yield tests have further confirmed the superiority of N. P. 710 in U. P., Madhya Bharat, Saurashtra and West Bengal, of N. P. 718 in Delhi, Rajasthan and Orissa, of N. P. 761 in Bihar and parts of Orissa, and of N. P. 770 and N. P. 809 in the northern hills. These varieties are fast spreading in these tracts and, consequently, there has been a heavy demand on their seed. The indents from the various Community Project Centres, State Governments and private growers totalled 7,675 maunds; of this, only 2,675 maunds could be supplied from the stocks of the Institute and its substations.

(ii) *Rust resistant linseeds.* Among the older rust resistant strains, N. P. (R.R.) 5, 9, 45, 439 and 440 have again given very good performances in northern and eastern India. In central and peninsular India, N. P. (R.R.) 204 and 267 have done well. Some promising rust resistant selections have been obtained during the year from advanced hybrid generations; of these, four selections have given remarkable performances.

(iii) *Chilli.* For work in this crop, especially for breeding for resistance to fungal and virus diseases, a comprehensive collection comprising indigenous and exotic varieties and wild species of *Capsicum* is being built up. Two types, Puri Red and Puri Orange, appeared to be remarkably free from mosaic disease in the field.

(iv) *Vegetables.* This work was in progress at Delhi and at the Central Vegetable Breeding Substation of this Division at Katrain (Kulu Valley). Seed of the European-type vegetables, such as cauliflower, cabbage, etc., has so far not been commercially produced in this country. Consequently, large quantities of such seed are imported annually. The main object of the substation at Katrain is to evolve improved varieties of vegetables, especially of the European-type, and conduct experiments which would enable their seed production in India. A notable success achieved during the year relates to the production of seed of late cauliflower of the snow-ball types which was unaccomplished so far in India.

A number of varieties in tomato, garden pea, onion, and sweet potato have been added to the list of improved varieties as a result of work done during the year.

During the year, 5,200 lbs. and 3,127 lbs. of vegetable seeds were produced at Delhi and Katrain respectively, for distribution to growers. About 54 maunds of vine cuttings and 16 maunds of tubers of sweet potato were distributed to Community Project areas and to several private indentors.

(v) *Vegetable Seed Testing.* The laboratory for seed testing work was equipped and a beginning was made towards the testing of market samples of vegetable seeds, for fixing standards for purity, germination capacity, moisture percentage, etc. In future years, benefit of this seed testing service will be made available to the vegetable seed trade in the country. A seed museum of vegetable crops and weed-seeds is being organised.

(vi) *Maize.* Thirty-nine Indian and 44 foreign varieties were added to the collection. Seed of the two foreign varieties, Jellicose and Amarillo de Cuba, which gave very good performances at Delhi, was multiplied for large-scale tests at the Institute and in some Delhi villages.

720 inbred lines were put under top-cross tests; 90 single and double crosses were also tested for performance. The yield increases, over the check variety—K. T. 41, ranged between 34 and 84 per cent in the top-cross trial and between 24 to 46 per cent. in the single- and double-cross trials. The results have indicated that crosses between inbreds of Indian flint and foreign dent types would give still better performances. Hybrid seed of the high-yielding American hybrids, N. C. 27, Texas 26, Dixie 18, and U. S. 13, was produced at Delhi.

(vii) *Essential-oil bearing plants.* Work was done at Delhi, Pusa, Katrain, and Aliabada (Saurashtra). Indigenous and exotic collections of *coriander* (*Coriandrum sativum*), *somf* (*Foeniculum vulgare*), *jeera* (*Cuminum cyminum*), *ajwain* (*Carum copticum*), and *sua* (*Anethum graveolens*) were under study. The following are among those that gave very good performances: Coriander —I. C. 3745 (Jaipur); *somf*—I. C. 3678 (Satara); *jeera*—I. C. 3744 (Jaipur); *sua*—I. C. 3677 (Kolde-Bombay State). The data on *ajwain* are not yet at hand.

B. Cytology and Cytogenetics

(i) *Autopolyploidy.* Several tetraploid lines have been obtained in berseem (*Trifolium alexandrinum*) and *Senji* (*Melilotus indica*); the former showed vegetative vigour superior to that of the diploid and appears very promising.

(ii) *Monosome genetics.* In the wheat variety, Coneta Klein, the genes controlling awn development and ear shape were located in chromosomes 3, 8 and 10, and chromosome 9, respectively.

(iii) *Use of embryo-culture technique.* The object of this work is to evolve techniques for artificially culturing young embryos, of intergeneric and interspecific crosses, which tend to abort. Suitable media for the culture of wheat, tomato, jute, and *Brassica* embryos were standardised.

(iv) *Use of radio-active isotopes for inducing mutations in crop plants.* Work was started on the induction of mutations in a number of crops, especially in wheat and cotton, through the use of the radio-active isotopes, P32 and S35, and X-rays, ultra-violet rays and fast neutrons. Radiation with P32 led to early flowering in the varieties treated. Cytological studies showed that treatment with fast neutrons causes numerous chromosome breakages without affecting survival of plants; these radiations thus appear to be useful in polyploid plants where many chromosomal changes are necessary to produce phenotypic or physiological changes.

(v) *Grasses.* Accessory chromosomes were recorded in *Panicum coloratum.* The African species, *Pennisetum ramosum*, was found to have $2n=10$ chromosomes, suggesting that the basic chromosome number for the genus is 5.

(vi) *Bhindi* (*Abelmoschus spp.*). *A. manihot* var. *pungens* and *A. manihot* var. *tetraphyllus* were both found to possess $2n=138$ chromosomes. The F_1 hybrid between them is sterile. Japanese workers have reported $2n=68$ chromosomes for *A. manihot*. These facts indicate the necessity of a cyto-taxonomic revision of this material.

C. Crop Physiology

With a view to finding out a suitable index to assess the degree of drought resistance in wheat, periodical determinations were made, after anthesis, of the green area on the leaf, stem and ear in a number of varieties grown with and without irrigation. The results indicated varietal differences, in respect of these characters, but no correlation with yield. Thus, under drought, yield seems to primarily depend on grain number per ear and grain size.

During the year under report, hormonal sprays did not improve the yield of wheat, but increased the weight of seed cotton and *toria* seed by about 20 per cent.

The weedicide, CMU, again showed itself to be a promising check on the growth of the nefarious weed, *kans* (*Saccharum spontaneum*), as reported last year.

D. Plant introduction

During the year, 1861 samples of seed and other planting material were introduced from abroad and 859 samples from within the country. The following are among the important introductions.

(*a*) *Tomato.* The varieties, Wiltmaster, Manalucie and Bison from the U. S. A.

(*b*) *Water-melon.* "Shin Yamato", a very sweet Japanese variety having cream-coloured flesh.

(*c*) *Musk-melon.* "Delicious 51" and "Minnesota Honey" from the U. S. A.; both are sweet and the former is reported to be wilt resistant.

(*d*) *Strawberry.* The varieties, "Florida 90" and "Dresden" from the U. S. A., and perennial strawberry from England.

(*e*) *Cotton.* A number of varieties of *Gossypium hirsutum* and *G. barbadense* from the U. S. S. R.

(*f*) *Papaya.* A hermaphrodite variety from Australia.

(*g*) *Grasses. Setaria sphacelata* and *Chloris gayana* from Australia; they put up luxuriant leafy growth and are resistant to drought and cold.

(*h*) *Tabebuia spp.* from the U. S. A. These are ornamental trees.

E. Horticulture

So far, a total of 17½ acres, out of the 30-acre orchard area, has been planted to several varieties of fruit trees, such as mango, citrus, grapes, papaya, guava; the remaining area was being developed. The planted nursery area now covers about 2½ acres comprising about 14,400 saplings of various fruit trees. About 1,400 saplings were sold to private indentors.

SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

A. Agricultural Chemistry

(i) *Nitrogenous fertilizers.* Further experiments on wheat confirmed that ammonium chloride is as efficient as ammonium sulphate as a nitrogenous fertilizer. Application of sodium chloride at 300 lbs. per acre in combination with 200 lbs. N as ammonium sulphate stimulated the yield of wheat by 76 per cent. as compared to ammonium sulphate alone. This effect is attributed to sodium.

Ammonia applied in irrigation water as a nitrogenous fertilizer showed significant response on wheat and paddy. On wheat the response was inferior to that obtained with ammonium sulphate due to loss of about 26 per cent. of the added nitrogen.

(ii) *Dicalcium phosphate.* Comparative trials with dicalcium phosphate and superphosphate fertilizers for the third year showed no direct response on wheat or paddy, when applied alone or in combination with nitrogen. The residual effect of both the types of phosphorus on berseem crop was however significant and the response to superphosphate was significant over dicalcium phosphate.

(iii) *Compost.* Pot experiments with berseem have shown that prior treatment of superphosphate and crushed bones by adding the same to actively fermenting compost material gave higher crop yields than a mixture of unfermented phosphate and separately fermented compost, containing equivalent quantities of phosphate and nitrogen.

B. Soil Chemistry

(i) *Inorganic fertilizers.* Wheat fertilized with inorganic fertilizers for the third year in succession showed no deterioration in yield or chemical composition as compared to wheat manured with farm yard manure or a combination of organic and inorganic manures.

C. Soil Survey

Studies on the laterites of Malabar showed similar morphological features irrespective of the nature of the underlying rocks. The differences in the native rocks are however, reflected in the chemical composition of the profiles, particularly in the iron, alumina, and silica contents.

D. Physical Chemistry

(i) *Clay humus complex.* The formation of Tuylins fertile group of clay-humus complexes was found to be promoted by SiO_2 groups on the surface of the clay. Fe_2O_3 groups promoted the second group rather than the first while Al_2O_3 had no effect on these two groups.

(ii) *Clays and clay minerals.* Strong interaction was noticed in mixtures of some soil clays with clay minerals invalidating many additive laws. Although this can be expected from the reactivity of these constituents, it has far reaching significance in evaluating the mineralogical composition of soil clays.

E. Organic Chemistry

(i) *Pesticides.* Ethoxymercuric chlorides of high mercury content have been prepared from camphene and longifolene, two inexpensive raw materials. These products have been found to show very high fungicidal activity.

(ii) *Antioxidants.* Resinoids obtained from *Myrestica malabarica* seeds and mace, after suitable processing, have shown remarkable antioxygenic properties.

(iii) *Analytical.* Cold percolation method previously developed for determination of oil content in small sample of oil seeds has been so modified that it can be used for the determination of iodine value and tocopherol contents of oils. Method has also been developed to determine iso-oleic acid in fats and oils. A technique has been developed to determine the saturated acid content in small amount of fixed acids.

F. Physics

(i) *Spectrography.* A direct current arc method for the estimation of micro-elements in citrus leaves was developed using copper electrodes. Boron, manganese and zinc can be estimated with this economic method down to 1, 3 and 10 ppm., respectively, in dry citrus leaves.

G. Biochemistry

(i) *Quality of maize.* Maize grains raised with different manures and fertilizers were analysed for their nutritive value. Their contents of protein, thiamine, as well as total and phytin phosphorus, have been markedly affected by different manurial treatments.

(ii) *Foliar application of urea.* Field experiments carried with spraying of as low as one per cent. urea on wheat significantly increased the yield and protein content of wheat. The maximum increase in the protein content of wheat was obtained by 6 per cent. urea when sprayed thrice. Foliar application of urea also increased the 1,000-kernel weight and caused a highly significant reduction in the percentage of mottled grains.

(iii) *Micro-element fertilizers.* Field experiments for three years have shown that Cu, Mn, Zn and Mg, whether applied singly or in combination to Delhi soil significantly increased the yield of wheat the maximum increase being with manganese. Mn or Zn significantly increased the protein content of wheat as well. Foliar application of Cu, Zn and Mg also significantly increased the yield and protein content of wheat, the maximum increase in the yield and protein content being with magnesium and zinc respectively.

H. Microbiology

(i) *Cowdung gas plant.* A simple and efficient design of cowdung gas plant suitable for village homes was developed and 6 such plants, set up in six Delhi villages, worked satisfactorily during this year.

I. Soil testing

Fifty field experiments have been laid down in the cultivators' fields in the 19 Delhi villages on the basis of soil tests conducted. Soil test summary maps of Quamaruddin Nagar village and Alipore Community Project, showing the nutrient status of different constituents, have been prepared.

J. Radiotracer investigations in soils and fertilizers

(i) *Phosphorus fertility status of soils.* Experiments on paddy and wheat with radioactive superphosphate on 31 different soils brought from various soil-climatic regions in the country showed that the response to phosphorus was much marked in about 50-60 per cent. of the soils used and the response curve flattened out between 80-160 lbs. P_2O_5 per acre application. The percentage of the applied fertilizer utilized by wheat varied from 8·5 to 20·7 while that for paddy from 2 to 22·7. It is important to note how little of the applied fertilizer was actually used by the crops.

Surface phosphorus was determined in a number of soils used in green house work by isotopic exchange with P32. The value at 60 hours was found to correlate significantly with A value (for 13 soils r=+0·798) and available phosphorus by Olsen method (for 21 soils r=+0·771).

(ii) *Placement studies.* In a placement experiment with tagged superphosphate on paddy at the Institute Farm at New Delhi, surface application was compared with placement in pellet form at 3″ and 6″ depths. Maximum utilisation of the applied fertilizer was noticed from the surface application. The result is of great significance and further work is in progress.

(iii) *Available phosphorus.* Comparison of various current methods for determination of available phosphorus in soils was carried out and NaHCO3 method was found to be the best. A new method utilizing versene and fluoride for estimation of available phosphorus in soils was developed. The method gives highly significant correlations with yield responses to phosphorus applications.

K. All India Soil Survey Scheme

Under the All India Soil Survey Scheme, four regional centres are being established in the Red Soil, Black Soil, Laterite Soil and Alluvial Soil regions. Certain preliminary work has been started in the Red and Alluvial Soil regions at Bangalor and at Delhi respectively.

ENTOMOLOGY

(*a*) *Systematic Entomology.*—Work on the taxonomy of the Indian social wasps indicated that two of the genera were easily separable on genital characters. A review of the family of the Indian Lady bird beetles, an important predatory group of insects, was completed. Cataloguing of the tribes in two families of the Indian parasitic wasps, as also of the family of Indian Robber flies. was also completed.

(*b*) *Insect Parasitology.*—In their natural habitat almost all crop pests are kept in a condition of equilibrium to a great or lesser extent by their natural enemies, in the main, parasites and predators. A survey was, therefore, planned and started on an all-India basis to collect new and promising parasites of important crop pests. Studies on the effect of nutrition on the fecundity, longevity and sex ratio of a few parasitic wasps were continued. Adults reared on the host fed with jowar and 8 per cent yeast gave the best results in so far as the longevity, fecundity and sex ratio of the larval parasite were concerned. Studies on the effect of the various synthetie diets on host-larval growth showed that development was best in *jowar* and riboflavin @ 12-24 micrograms/gm. of diet. In the case of a chalcid wasp, parasitic on Pyrilla eggs, feeding the wasp with different sugar solutions raised its longevity significantly. The biology and morphology of a few parasites of the pea leaf miner were also studied.

(*c*) *Ecology and Toxicology.*—Ecological studies on 'Phadka' grasshopper showed that no nymphs emerged from egg pods buried in an inverted position while 12 per cent and 50 per cent of the nymphs emerged from the egg pods buried sideways and in the normal position, respectively. Thus the beneficial effect of ploughing was indicated. Dieldrin, aldrin and gamma-BHC dusts, tried against first instar nymphs, proved equally effective against the pest. Studies on the *jowar* borer indicated that the pest does not undergo a true physiological diapause although development is considerably slowed down. Also it was shown that the climate of any part of India could not act as a limiting factor against the existence of this pest. For the first time it was possible to rear the painted bug to an adult stage on mustard seeds. In an effort to evolve a spraying schedule against mustard aphid, it was observed that four sprayings of gamma-BHC and Pestox III during the active season of the pest were effective. The temperature effect of insect susceptibility to fumigation by carbon disulphide and ethylene dichloride, as observed on a common stored grain pest, showed that there was a complex interaction between prefumigation, fumigation and post-fumigation temperatures on the mortality of insects. Bioassay studies showed that DDT film is the most toxic among the various insecticides tried, namely DDT, endrin, isodrin, dieldrin, aldrin and gamma-BHC, against

adults of a weevil (*Myllocerus*). Contrary to normal expectation, carbon tetrachloride was found to be superior to the E. D. C. T. mixture when used in bins containing wheat. In tests with pyrethrum, the synergistic effect of the piperonyl butoxide was demonstrated by the fact that as low a dose of 0·0025 per cent of pyrethrin emulsion alone gave a mortality of 63·3 per cent among adults of the red pumpkin beetle, whereas the same dose with piperonyl butoxide gave 96·6 per cent mortality.

On the studies of the effect of contact insecticides on the infestation of stored grains it was found that at Delhi the infestation in cowpeas went up to 87·2 per cent in the untreated portion but in the grains treated with some dusts it ranged between 3·6 per cent and 7·2 per cent. Similarly, the infestation in wheat went upto 53·3 per cent in the untreated lot at Pusa (Bihar) as against 0·0 per cent to 7·7 per cent in some of the dust treatments.

Studies on the 'Khapra' beetle, one of the most resistant among the stored grain pests, revealed that the extraordinary resistance of the larval stage is lost even at the pupal stage and the adult is quite susceptible. It appeared that the insecticides, lindane, aldrin and dieldrin can easily be depended upon for the safe preservation of at least seed grain against this dreaded pest.

(*d*) *Insect Physiology.*—The chorion of a few of the dipterous flies under study appeared to have some lipoid on the outer surface, whereas the inner surface has a complete layer of lipoid to resist the entry of aqueous solutions. These studies, which are in progress on a number of other inspect pests and parasites, would be helpful in finding out suitable ovicides, of which there are very few today.

(*e*) *Entomological investigation with the help of radio-active isotopes.*—Preliminary studies indicated that the parasite of potato tuber-moth, fed with 25 μc of P^{32} per gram of 10 per cent glucose solution per parasite, did not become radio-active to the tracer level whereas doses of 50 μc and 100 μc under similar conditions made them radio-active. Parasites feeding on normal 10 per cent glucose solution were irradiated with P^{32} and it was observed that a dose of 250 μc produced little activity in the parasites while a dose of 500 μc produced slight activity after 24 hours of irradiation. Full grown host larvae were made radio-active and later on given for parasitisation. The viability of the eggs and the fecundity of the parasite seemed to have been adversely affected.

MYCOLOGY AND PLANT PATHOLOGY

A. *Plant Pathology*

(i) *Wheat:*

Rusts: Three hundred and forty-six samples of black, brown and yellow rusts were analysed, which yielded: races 21, 24, 34, 40, 42, 42-B, and 75 of black rust; 10, 11, 20, 26, 63, 77, 106, 107 and 108 of brown rust; and 13, 19, 20, 31, A and E of yellow rust. Indications of two new races of brown rust and one of black rust

(closely resembling race 17) were obtained. Race 77 of brown rust, first reported from 1953-54 crop, was found in the collections from Punjab, Uttar Pradesh, Madhya Pradesh, Bombay and Madras on the improved wheat varieties like N. P. 111, N.P. 745, N.P. 760 and N.P. 770. Races 21 and 42 of black rust, 10, 20 and 63 of brown rust, and 19 and A of yellow rust were predominant. A new virulent biotype of race 21 of black rust, designated as 21-A, was picked up.

Muhelenbergia hugelii, a perennial grass growing wild in the Upper Simla Hills, was found to be naturally infected with yellow rust. This grass was also found to harbour another rust which is under study. A large number of species of *Agropyron* and *Aegilops* were found to be susceptible to all the three rusts in artificial inoculations.

Extensive survey of Himachal Pradesh, as also of the Kulu and Lahaul Valleys, showed that the rusts could survive during summer months in various localities. The aecidial stage on *Berberies*, collected from these areas, did not appear to be connected with black rust of wheat. *Berberis jaeschkeana*, collected from Lahaul Valley, was found to be resistant to black rust of wheat under glasshouse conditions as judged by its reaction to races 21 and 42.

Selfing studies with races 21 and 42 of black rust have shown that the two races are heterozygous.

In all, 17,909 plants of wheat varieties, their crosses and progenies were tested in the seedling stage. E. 4613 was found resistant to all the races of black and brown rusts and E. 1844 to all the races of yellow rust except race 19. More than 125,000 plants were tested in the adult stage after artificial infection and promising material was selected. A combination of races 21 and 40, maintained on *Agra local* wheat for 6 successive generations, did not show any appreciable change in the frequency of the two components.

Loose Smut :— Out of the 96 wheat varieties tested for their resistance to the disease at Delhi and Simla, 72 remained free from infection and may be considered as promising from the point of view of loose smut resistance. N.P. 721, E. 220, E. 957 and W. 206 Pl.—40 have been found to be resistant to the disease during the last three tests. Some wheat varieties of the N.P. 700 and N.P. 800 series, as also exotics and hybrids, which were found smut-free in the last year's test, did not show infection again this year. Some indication of physiologic specialization within the pathogen was obtained in preliminary tests.

Bunt :—In the varietal resistance tests against the Hill Bunt at Simla, four wheat varieties, out of the 147 under test, proved resistant. Similar tests with Karnal Bunt at Karnal indicated that at least 17 varieties, out of the 99 under test, were susceptible. It was further observed that chlamydospores of Karnal Bunt, pretreated with lactic, citric and oxalic acids, gave better germination than the untreated spores. Preliminary studies have shown that there are at least two physiologic races each of *Tilletia foetida* and *T. caries* in this country.

(ii) *Barley :*

Rust : Fourteen samples of black and yellow rusts were analysed and races 21, 34, 40 and 42 of black rust and 19 and G of yellow rust were met with. The total number of plants tested in the seedling stage were 1,491 ; and B. 240, B. 241 were found resistant to all the races of yellow rust except race G. Thirty-six varieties and crosses were found to be completely free from infection when tested with a mixture of black and yellow rust races in the adult stage.

Evidence was obtained that there were at least two physiologic races of leaf rust of barley (*Puccinia simplex*).

Smut : In varietal resistance tests against loose smut, with 28 barley varieties, B. 47, B. 237 and B. 240 proved resistant. Cross-inoculation tests with wheat and barley loose smut fungi showed that they were host-specific.

(iii) *Sugarcane :*

Red Rot : Twenty-eight isolates of the pathogen, including those recently obtained from the red-rot epidemic areas of Punjab, were tested on the 10 standard cane varieties for study of physiologic forms, but no evidence of physiologic specificity was obtained. In the varietal resistance tests, 182 cane varieties were tested by the plug method and 96 by the nodal-infection method. S. G. 227/9 was found to be resistant by the nodal-infection method. In addition, 74 varieties by the plug method and 5 by the nodal-infection method were found to be moderately resistant. In the mixed-inoculum experiment, a mixture of dark and light type isolates generally gave more infection than the individual strains or other combinations of these isolates.

Smut : In the varietal resistance tests carried out with 189 cane varieties, 40 varieties gave less than 5 per cent infection and may, therefore, be considered as resistant. In the highly susceptible varieties, infection upto 100 per cent was obtained.

(iv) *Linseed :*

In all, 108 rust samples (92 from 1954-55 crop and 16 from 1955-56 crop) were analysed and all the five Indian races of *Melampsora lini* were obtained. *Linum trigynum* was found to be immune to all the 5 Indian races of the rust. In adult resistance tests with 160 linseed varieties, 119 proved resistant.

(v) *Pigeon pea :*

Wilt : Out of the 20 pigeon pea varieties tested for their resistance to the disease, the improved strains, C. 15 (W.E.), P_3 and P_{48}, did not develop wilt either in the pot or the field test.

(vi) *Bajra :*

Green-ear disease : Oospore material of *Sclerospora graminicola*, after weathering during winter alone, did not germinate, whereas that exposed to both summer and winter germinated satisfactorily.

B. *Antibiosis*

An ionic exchange chromatographic procedure, using Amberlite Cationic resin IRCA-50 for separating the *Bacillus subtilis* antibiotic, has been worked out. The antibiotic was produced in soil supplemented with roots of *arhar* or pea or *Melilotus indica* and small quantities of glucose. It was found to remain stable in soil for about a month. More antibiotic was produced in sterilized soil than in unsterilized soil.

C. *Physiology of Fungi*

Further evidence was obtained that glucose-1-phosphate was essential for the sporulation of *Lophotrichus ampulus*. Use of purine and pyrimidine analogues indicated that adenine was possibly one of the essential growth factors for *Puccinia graminis tritici*. Eight strains of fungi were found to be capable of bringing about one or both the steps of nitrification to varying degrees.

D. *Effect of Atomic Radiations on Fungi*

Spores of *Collectotrichum falcatum*, *Puccinia graminis tritici*, *Phycomyces blackesleeanus*, *Ustilago tritici* and *Lophotrichus ampulus* were treated with low amounts of P^{32} up to 20 microcuries per ml. for varying periods. Subsequent cultural studies showed no discernible changes in any of these organisms, except in *L. ampulus* which appeared to have produced two non-sporulating strains.

Soil treated with radio-active phosporus for periods ranging from one to three months was examined for quantitative and qualitative changes in the flora of fungi and actinomycetes. In the initial activity range of about 90 to 400 microcuries per 10 gms. of soil, an increase in the numbers of fungi and actinomycetes was noted at the lower levels up to about 180 microcuries. The numbers dropped at higher levels, but were still more than in untreated controls. No qualitative changes were apparent at any level.

E. *Fungicides*

Replicated field experiments were continued to determine the relative efficacy of 8 commercial fungicides on the emergence, stand and yield of maize, *bajra*, wheat and barley crops. A majority of the seed dressings tried showed beneficial effect. Ceresan, in the case of maize and *bajra*, Agrosan GN in the case of wheat, and Spergon in barley were the most effective fungicides and gave maximum increase in grain yield.

In the Aretan treatment of sugarcane setts, appreciable increase in the number of millable canes and yield of crop was observed in the plots planted with the treated setts.

F. *Bacterial Diseases*

Studies on yellow slime ("tundu") of wheat, leaf spot of pomegranate and Citrus canker were continued. In the case of "tundu" disease, presence of the pathogen (*Corynebacterium tritici*) was demonstrated in the growing points of the infected wheat seedlings.

G. *Virus Diseases*

'Grassy shoot' disease of sugarcane, as also 'Line pattern' and mosaic diseases of plum, were established to be of virus origin. *Hibiscus pandurifornis* has proved immune to yellow-vein mosaic of *bhindi*. In the varietal resistance tests against small leaf disease of cotton, 4 varieties (Dhar Cambodia, Buri American, Parbani American and Indore 2) of *Gossypium hirsutum* were found to be resistant and two inter-specific hybrids, 170 - CO_2 and 134 — CO_2, proved to be immune. 'Foorkey' disease of large cardamom was successfully transmitted by the banana aphid, *Pentalonia nigronervosa*. Yellow mosaic of *mung* was transmitted by grafting and through white flies (*Demiosa tabaci*). *Myzus persicae* and *Brevicoryne brassicae* were found to be the vectors of mosaic diseases of *Brassica juncea* and *Hesperis matronalis*. In addition, *Aphis malvioides* also transmitted the latter disease. Safflower mosaic was transmitted by *Aphis gossypii* and *Rhopalosiphum pseudobrassicae* and Zinnia mosaic by *Aphis gossypii* and *Myzus persicae*. Phyllody disease of sesamum was transmitted to *Crotalaria striata*, *C. incana* and *C. verrucosa* by the insect vector, *Deltocephalus* sp.

Fundamental studies on the inhibition of potato virus X were continued and thiosemicarbazide and thiouracil were found to inhibit the virus multiplication. The sugarcane and maize mosaic viruses were found to be related strains of the same virus as judged by the cross-protection tests. Southern Sunnhemp Mosaic and *Crotalaria* Mosaic (Delhi) viruses were purified.

The jassid, *Eutettix phycitis*, acquired the virus causing "Little-leaf" of *brinjal* from diseased plants in a minimum feeding period of one hour. The nymphs were able to acquire the virus in all the stages except the first instar. *Aphis gossypii* was able to transmit the banana mosaic virus after a feeding period of 10 minutes. The virus causing mosaic of *Brassica juncea* was found to be non-persistent in the aphid vector (*Brevicoryne brassicae*).

H. *Systematic Mycology*

Taxonomic studies on miscellaneous Indian fungi were continued and, in this connection about 100 interesting specimens were studied. A new genus, *Vasuderalla*, of *Sphaeropsidales*, with *V. sporoboli* as the type species, was established. In addition 2 new genera and 4 other genera, not hitherto reported from India, were recorded. Twenty-two new species and 47 new hosts for the previously known species were encountered. *Alternaria zinniae* Pale was recorded for the first time in India and two new hosts of *A. solani* were established. Eight species of *Cercospora*, not so far known in India, were recorded. Biometric studies of *Albugo Ipomoeae-Panduratae* on different hosts has provided a basis for dividing the species into at least two inter-specific groups.

3. GENERAL FEATURES OF THE REPORT

(i) *Land and buildings.*—The building of eth Agricultural Economics section was completed and occupied during the year. Two tubewells, at this Institute, for supply of water for irrigating crops were sunk. Two rooms in the Agronomy Division, hutments in village Nangloi Jattan, one coal bunker and gas holder pit in the

Gas House under the Chemistry Division were constructed. The construction of residential quarters (double storeyed) in the new area. Proto-type Soil Testing Laboratory, extension to Mycology and Agronomy Divisions, machine shed in Entomology Division, green house for Chemistry Division, glass-house Botany Division, lining of main irrigation channels, museum for agricultural implements, and workshop for Agricultural Engineering Division were among the major works taken up during the period under report.

(ii) *Post-graduate training.*—Ninety-one students, out of a total of 234 applicants, were selected during the year for the regular post-graduate training in different subjects.

7 students were given short course training in different subjects.

12 Honorary Research Workers were admitted in the different Divisions.

Fifty-four students successfully completed their studies in the post-graduate course and were awarded the associateship diploma of the Institute. A list of theses presented by these students is given in Appendix II.

(iii) *Library.*—The total number of publications received during the year by way of exchange and purchase was 4,136. Sixty new periodicals were added to the library during the same period. Out of a total of 6,691 books issued during the year 769 were sent to scientific workers in the States and Universities. The Reading Room was used by 10,069 visitors and 87,132 books were consulted.

References to literature on various subjects were supplied to the Ministry of Food and Agriculture, Indian Council of Agricultural Research, State Departments of Agriculture, Universities and to individual scientists. Some of these subjects were :—

Saw-fly ; agricultural pests on tobacco, coconut, cotton and tea ; plant ecology ; Hindi books and journals on agriculture ; Bignonia (*Pyrostegia venusta*) ; Hindi publications on vegetable growing ; paddy cultivation ; oats, Japanese method of paddy cultivation ; breeding of wheat, rice, potato, tobacco, sugarcane, cotton, etc. ; bee-keeping ; bibliography on vegetation, grasses and grasslands ; ginger ; and agriculture and related subjects.

(iv) *Advisory work.*—The Institute, as in previous years, attended to a large number of requests for expert advice and help on agricultural matters both from official and non-official sources. The types of problems handled are mentioned below :—

Agronomy.—General cultivation practices, Japanese method of rice cultivation, and distribution of seeds of improved varieties.

Botany.—Identification of plant and seed material, control of weeds by chemical weedicides, soilless culture or 'hydroponics', information regarding the drug-yielding plant *Rauwolfia serpentina*, electron microscopic study of plant chromosomes, growing of grasses and legumes on lands reclaimed from *Lantana* infestations, use of *Prosopis* as a hedge plant, use of hormones on the maize crop, information regarding yield and quality of Russian Comfrey (*Symphytum asperrimum*) as a fodder plant.

Chemistry.—Analysis of soil, manure and water samples, specifications of the steamed bone-meal and of phosphatic fertilizers, methods of testing for fluoride and chloride in dicalcium phosphate fertilizer, conservation of human urine, chemical composition and biological value of pulse proteins, and use of chopped straw for preparation of compost in pits.

Entomology.—Identification of insect pests, control of insect pests and rodents, issue of health certificates and supply of coloured plates of insects.

Mycology and Plant Pathology.—Identification of pathogenic and taxonomic specimens and of fungal and bacterial cultures, fungicidal seed dressing and issue of health certificates for plant material.

Agricultural Engineering.—Selection and source of availability of suitable agricultural implements, and supply of working drawings of improved agricultural implements.

(v) *Research Schemes.*— (*a*) Work on the following schemes financed by the Ministry of Agriculture, Government of India, Indian Council of Agricultural Research, Indian Central Sugarcane Committee, and Indian Central Oilseeds Committee was in progress in the different Divisions of the Institute during the year under report :—

Serial No.	Title of the scheme	Division	Sponsored by
1	Key Village Scheme	Agronomy .	Ministry of Agriculture.
2	Scheme for agronomical studies on oilseed crops.	Do.	Indian Central Oilseeds Committee.
3	Scheme for the collection of indigenous and exotic pasture grasses and legumes, their testing and distribution, and their breeding for better agronomic characters.	Agronomy and Botany.	Indian Council of Agricultural Research.
4	Scheme for the improvement of maize in India.	Botany .	Do.
5	Co-ordinated scheme for investigations on micro-nutrients.	Do.	Do.
6	Co-ordinated scheme for the improvement of chillies.	Do.	Do.
7	Scheme for the improvement of essential oil-yielding plants.	Do.	Do.
8	Co-ordinated scheme for the improvement of musk-melon and water-melon.	Do.	Do.

Serial No.	Title of the Scheme	Division	Sponsored
9.	Scheme for the study of genetics and viability of algae from the viewpoint of their use in agriculture.	Botany	Indian Council of Agricultural Research.
10.	Scheme for physiological investigations on autotetraploids of some oilseed crops.	Do.	Indian Central Oilseeds Committee.
11.	Scheme for cytogenetical studies in some oilseed crops of India.	Do.	Do.
12.	Scheme on radio-tracer and related investigations for assessment of soil fertility.	Chemistry .	Ministry of Agriculture.
13.	Scheme for the studies on the chemical composition and nutritive value of wheat.	Do.	Indian Council of Agricultural Research.
14.	Scheme for research on the examination of rapid methods of soil test for soil survey work.	Do.	Do.
15.	Scheme for making soil analysis in Jammu & Kashmir State (From 5th Oct. 1955 to 4th April 1956).	Do.	Do.
16.	Scheme for research on termites . .	Entomology .	Do.
17.	Co-ordinated plant virus research scheme .	Mycology .	Do.
18.	Co-ordinated plant virus research scheme (Eastern Zone).	Do.	Do.
19.	Scheme for the development of Herbarium Cryptogamiae Indiae Orientalis.	Do. .	Do.
20.	Scheme for research on the diseases of sugarcane.	Do.	Indian Central Sugarcane Committee.
21.	Linseed Rust Scheme	Do.	Indian Central Oilseeds Committee.
22.	Scheme for research on virus diseases of oilseed crops.	Do.	Do.
23.	Scheme on production, demonstration, trial and popularisation of agricultural implements.	Agricultural Engineering.	Do.

(*b*) Work on the following schemes was taken up under the Second Five-Year Plan during the year under report.

Serial No.	Title of the Scheme	Division
1.	Project for irrigation investigations (From 1st March, 1956)	Agronomy
2	Project for the setting up of a post graduate course in Agricultural Extension (From 1st March 1956)	Do.
3	Scheme for investigations on weed control (From 1st March, 1956.	Do.
4	Scheme for studies on the *chapati* making and baking qualities of Indian wheats (From 3rd December, 1955)	Botany
5	Scheme for control of bunt in wheat (Botanical portion) (From 22nd July, 1955).	Do.
6	Scheme for cytogenetic studies on the use of radio active isotopes (Form 15th September, 1955).	Do.
7	Scheme for the setting up of a Seed Testing Station (From 1st October, 1955).	Do.
8	Scheme for the establishment of a unit for embryo-culture work (From 15th September, 1955).	Do.
9.	All-India Soil Survey Scheme (From 18th September, 1955) .	Chemistry
10	Scheme for cartographic laboratory for soil mapping (From 14th December, 1955).	Do.
11.	Scheme for working electron microscope (From 20th September, 1955).	Do.
12.	Scheme for radio tracer investigations (From 1st March, 1956)	Do.
13.	Scheme for a Unit of Physics (From 28th March, 1956) .	Do.
14.	Scheme for biological testing and certification of insecticides (From 20th September 1955).	Entomology
15.	Scheme for research on insect physiology (Form 20th September, 1955).	Do.
16.	Scheme for establishing a unit for storage pest ecology (From 26th September, 1955)	Do.
17.	Scheme for study of beneficial parasites of pests of agricultural crops.	Do.
18.	Scheme on Indian honey-bee (at Pusa) (From 1st March, 1956)	Do.
19.	Scheme for entomological investigations with the help of radio-active isotopes (From 1st November, 1955).	Do

Serial No.	Title of the Scheme	Division
20.	Co-ordinated Scheme for Plant Virus Diseases (From 16th November, 1955)	Mycology
21.	Scheme for setting up of Seed Testing Station (From 11th November, 1955) (Mycological portion)	Do.
22.	Scheme for the use of atomic energy in plant pathological research (From 4th October, 1955).	Do.
23.	Scheme for the study of bacterial plant pathogens (From 10th November, 1955).	Do.
24.	Scheme for control of bunt in wheat (Mycological portion) (From 11th November, 1955)	Do.
25.	Scheme for testing of efficacy of fungicides (From 30th September 1955).	Do.

(vi) *Collections and Herbaria.*—The foreign plant introduction and indigenous collection during the year numbered 1,861 and 859 items respectively, bringing the total collection to over 14 000 items. Important introductions were in the case of tomato, water-melon, musk-melon, strawberry, cotton, papaya, some grasses, and ornamental trees. Fifty specimens were added to the herbarium maintained in the Botany Division. The number of specimens now totals 67,050.

Thirty-three fungal and bacterial cultures were added to the Indian Type Culture Collection in the Mycology Division, bringing the total number of cultures in stock to 990. About 120 cultures were distributed to various scientific workers and institutions in the country and abroad. Studies on mineral oil and soil-preservation of fungi were continued. In all 1,501 mycological specimens (both Indian and foreign) were added to the Herbarium, bringing the total number of accessions to 24,185. One hundred and ten specimens, as also 41 coloured plates, of important plant diseases were supplied to various Indian and foreign workers. An Exsiccati Set on "Indian Cercosporae" was completed and issued to important foreign herbaria and another set on "Indian Uredinales—Fascicle III" was under preparation.

The "National Pusa Collection" of insect specimens was maintained as usual. Eight lots comprising ninety-eight insect specimens were received as donations from various sources, partly for studies and partly for the collection. Sixteen specimens of Pyrocoridae were received back duly after specific determination and incorporated in the Collection. One hundred and forty-eight named specimens from the general collections were donated to seven different organisations and forty-eight specimens of undetermined Diopsidae were sent for studies to M. Paul Ardo of the University Zoological Institute, Lund, Sweden. The identification of forty-five lots of insect specimens received from outside sources, by comparison with the material in the National Pusa Collection was in progress. It has been decided to introduce the tray system to accommodate all the duplicates of a particular species, as is being done now in some of the great museums of the West. For the wet collection, a new kind of weighted stand was being improvised to hold the different stages in the life cycle of a particular species ; this will enable the indentification, in the course of time, of all the different stages of an insect.

(vii) *Intensive Cultivation Scheme.*—Considerable progress was made in the development of the 19 villages which was taken up in August, 1950. A total of 777 field demonstrations (including 250 on fertilizers), as against 696 in 1954-55, were arranged ; they related to the use of new varieties, manures and fertilizers, improved cultural practices, and better implements and application of insecticides and fungicides. The area saturated with the improved wheat variety, N.P. 718, was 2.099 acres. Area rogued to maintain purity of seeds was 469 acres. The results of demonstrations with improved varieties have shown increase in yields in respect of wheat N.P. 718, barley N.P. 13, gram N.P. 58, and *bajra* T. 55 over the local varieties. Soil maps of all the villages have been prepared. Fuel gas plants have been installed in six villages and these are working satisfactorily. A total quantity of 575 maunds of fertilizers was sold to the farmers and 240 fruit plants were supplied to them.

(viii) *Meetings and Conferences.*—As usual, the Director, Heads of Divisions, and other officers of the Institute attended the meetings and conferences held under the auspices of the various Ministries of the Government of India, the Indian Council of Agricultural Research, various Commodity Committees, etc.

(ix) *Supply of pedigree seeds.*—As in previous years, the demand for N.P. seeds, especially of wheat, from the different States was quite heavy. Since the area available for seed multiplication purposes was limited, the supply of seeds fell far short of the demand. The following quantities of pedigree N.P. seeds of different crops were supplied by the Institute :

Crop	Quantity of seed distributed (in maunds)
Wheat	4,000
Oats	36·1125
Barley	16·39
Maize	20·89
Gram	35·9
Peas	156·075
Berseem	13·669375
Paddy	133·12875
Other crops	11·61
Sugarcane setts	1,686·50
Grasses and legumes	429 seed samples
Kudzu vine	1500 crowns
Lentil	1
Linseed	1
Hibiscus	·625
Sunn-hemp	20
Mung	1

(x) *Visitors.*—A large number of distinguished scientists and other dignitaries both from India and abroad, as well as Members of Parliament and high officials of Central and State Governments, visited the Institute. Important among the visitors were : Shri A. P. Jain, Minister for Food and Agriculture, Government of India ; the President of the Indian National Congress ; His Excellency Dr. Hatta, Vice-President, Republic of Indonesia ; His Majesty the Shah of Iran ; Their Majesties the King and Queen of Nepal ; the Maharaj Kumar of Sikkim ; and Their Excellencies Mr. N. A. Bulganin and Mr. Khrushchev of the Union of Soviet Socialist Republics.

PART II.

Reports of the Heads of Divisions for 1955-56.

Report of the Division of Agronomy (including Agricultural Research Sub-Station, Karnal.)

(Dr. P. C. Raheja)

I. *Weather and its effects on crops*

The records of the meteorological observations are summarised below :—

Month	Temperature				Relative humidity at 7 a m (local)	Rainfall in inches	Dep from normal	Mean wind velocity M/H	Mean hrs. of bright sunshine	Mean evaporation in inches per day (U S A. standard)
	Mean max. °F	Dep. from normal	Mean min. °F	Dep. from normal	%					
July, 1955 . .	96·0	+0·1	80·0	—0·8	74	4·69	—2·57	4·97	6·70	0·4131
August, 1955 . .	89·3	—3·0	77·9	—1·2	91	8·13	+2·74	3·30	5 14	0·2044
September, 1955 .	89·6	—2·0	75·6	—0·2	88	10·19	+5·54	3·57	7·18	0·2520
October, 1955 . .	84·2	—6·9	64·1	+0·8	91	4·39	+3·42		7 87	0·1769
November, 1955 .	80·4	—2·0	47·9	—1·8	82	0·00	—0·05		9·86	0·1613
December, 1955 .	72·0	—0·5	43·8	+1·1	93	0·00	—0·08	Instrument was out of order.	8·48	0·0992
January, 1956 . .	68 5	—3·6	42·6	—0·9	91	0·29	—0·44		7 69	0·0984
February, 1956 .	75·3	+1·1	42·4	—4·3	79	0·00	—0·79		9·79	0·1651
March, 1956 . .	83·9	—0·9	56·2	+0·9	79	0·47	—0·35	4·75	7·96	0·2353
April, 1956 . .	98·3	+0·7	66·1	—0·2	43	0·02	—0·22	5·16	10·00	0·4660
May, 1956 . .	107·1	+2·70	78·7	+1·9	44	0·00	—0·48	6·70	9·82	0·6157
June, 1956 . .	102·3	—2·4	82·4	—0·8	60	2·09	+0·63	7·64	7 37	0·5411

The monsoon broke towards the end of June, 1955. Droughty conditions prevailed in July which necessitated irrigating the *Kharif* crops. The precipitation received in September and October was helpful in sowing *rabi* crops without presowing irrigation. There was a fall of 6·9°F in the maximum temperatures in October. Light ground frost observed in December and January damaged the potato and tomato crops to a little extent. The minimum temperatures in February were down by 4·3°F. The winter rainfall was below normal.

The yields of principal crops grown in the farm are given below :—

Crop	1955-56		1954-55	Remarks
	Area (acres)	Average yield md./acre	Average yield md./acre	
Wheat	96·12	21 67	21·66	
Oats	59·87	20·49	21·23	
Peas	6·84	16·94	16·78	
Gram	70·00	7·18	5·44	
Berseem fodder	21·84	478·84	529·20	
Maize	18·3	15·43	14·00	
Sugarcane	7·74	582·75	697·90	

II. *Research projects*

The research programme of the Division was modified on the lines suggested by the Technical Committee. The experimental results are reported under the reorganised sections.

1. *Soil fertility section*

(i) *Building up of soil fertility through organic manures and inorganic fertilizers with and without a legume in the rotations :* The rotations followed in the experiment are(*a*) maize-wheat-maize-wheat; and (*b*) maize-wheat-maize-peas. During the year under report maize-wheat and maize-peas were grown. The fertility built up after the completion of the first cycle of rotation in 1953-54 was evident in 1954-55 when maize-wheat were grown under both the series. The yield of both the crops in the legume rotation was much higher than that obtained in the cereal rotation.

In regard to the response to F. Y. M., castor cake, NPK and NP on maize the treatments showed significant effects. The yields varied from 9·3 to 15·1 maunds per acre as against 6·5 to 9·3 maunds per acre obtained from the no manure control in both the series. Organic manures at 60 lbs. N/acre applied in full dose to maize gave higher yields than the fertilizers applied at half the rate to *kharif* and *rabi* crops (30-50-50). With wheat in the cereal rotation, fertilizers showed better response (26·3 md./acre) than organic manures (18·2 to 21·3 md./acre) and they were significantly superior to the control (16·7 md./acre). Peas also responded significantly to F.Y.M., castor cake, NPK and NP (29·9 to 33·9 md./acre) over the control (25·8 md./acre).

(ii) *Building up of soil fertility through organic manures and inorganic fertilizer with bajra and wheat in the cereal rotation :* The object of the experiment is to study the possibility of growing *bajra* and wheat in the same year, in conjunction with heavy manuring under irrigated conditions. Results were similar as obtained last year. *Bajra* after fallow gave significantly higher yield (19·5 md./acre) than *bajra* after wheat (15·7 md./acre). Wheat after fallow gave an yield of 22·1 maunds as against 8·6 maunds after *bajra*. The dose of 20 tons/acre F.Y.M. gave significantly higher yield (21·0 md./acre) as against 16·2 to 17·5 md./acre for lower doses of 2½, 5, and 10 tons per acre. Differences among the levels of nitrogen 0, 20, 40 lb./acre as ammonium sulphate were significant (16·5, 17·4 and 18·8 md./acre). Similar results were obtained with wheat. F.Y.M. applied to wheat at 20 ton/acre showed significant differences over 0, 2½ and 5 tons/acre levels (20·2 against 10·4 to 16·3 md./acre). These results indicate that high yields were not obtained under intensive cropping and manuring.

(iii) *Building up of soil fertility through organic manures, including green manure and inorganic fertilizers :* The residual effect of green manure with *guar*, F.Y.M. and castor cake and of the fertilizers N, P, NP and NPK was studied on maize and wheat. In this study each plot was split into two parts, one manured with ammonium sulphate at 30 lb. N for maize and 20 lb. N/acre for wheat. The residual effect of *guar* green manure was significant over other organic manures, as judged from the yield of maize. Further, the direct effect of fertilizer nitrogen was also exhibited to be significant over without top dressing of fertilizers.

(iv) *Effect of low doses of phosphate on berseem and after-effects on wheat :* In the third cycle of the rotation : *berseem-cowpeas* (3 years) followed by wheat after fallow and wheat after cowpeas (3 years), the second crop of berseem was harvested. The treatments super 8 lb. P_2O_5+F.Y.M. 56 lb. P_2O_5, super 64 lb. P_2O_5, F.Y.M. 64 lb. P_2O_5 and F.Y.M. 8 lb. P_2O_5+super 56 lb. P_2O_5 gave significantly higher yields (595·8, 522·2, 517·1 and 508·4 md./acre) than those obtained with 0, 16 and 32 lb. P_2O_5 levels. Similar results were obtained last year. Cowpeas grown after manured berseem did not show significant differences due to after-effects of phosphate levels.

(v) *Effect of phosphate with and without potash and/or nitrogen on berseem and after-effects on maize, cotton and wheat :* The experiment is being conducted in two series : (*a*) *Berseem* (fertilized)-*maize-berseem* (fertilized)-*cotton-wheat* ; and (*b*) *Berseem* (fertilized)-*maize-berseem-cotton-wheat.* Unfertilized maize was grown in both the series, followed by fertilized berseem in series (*a*) and unfertilized berseem in series (*b*). The yields of maize due to after-effects of fertilizers (17·1 to 20·6 md./acre)

were highly significant over the no fertilizer control (11·6 to 12·9 md./acre) in both the series. With berseem in the fertilizer series NPK (100-120-120) gave the highest yield of fodder (820·8 md./acre) followed by NP (791·1 md./acre), PK (766·6 md./acre) and P (736·3 md./acre) as against 170·6 md./acre from the control plot. In the unfertilized series, the trend of response due to after-effects was similar, but the yields were low (415·6 to 396·4 md./acre as against 141·6 maunds in the control). The results are in close conformity with those obtained in the previous two cycles of the rotation.

(vi) *Phosphate fertilization of Hubam clover and its after-effects on maize :* As reported last year, Hubam clover did not respond to phosphate manuring.

A summary of the results of maize grown to study after-effect is given below :—

Mainplot treatment—	Yield of maize grain (md./acre).
P_0-no. P_2O_5	17·28
P_1 ,, 40 lb. P_2O_5/acre	15·12
P_2 ,, 80 lb. P_2O_5/acre	14·00
P_3 ,, 120 lb. P_2O_5/acre	18·83
'F' test	Not significant
S. Em	± 1·227
Subplot treatment—	
1. Hubam grown for seed only	23·54
2. Hubam grown for seed after 1 cut for fodder	12·56
3. Hubam grown for green manuring	18·88
4. Hubam grown for green manuring after 1 cut for fodder	14·13
5. Hubam grown for green manuring after 2 cuts for fodder	15·90
6. Hubam grown for fodder only (3 cuts)	12·86
'F' test	Significant
C. D. (5 per cent)	7·01

Though maize showed higher yield in plots treated with 120 lb. P_2O_5 (18·8 md./acre), the difference over the control was not significant (17·3 md./acre). Maize grown after Hubam clover for seed gave significantly higher yield (23·5 md./acre) over green manuring with Hubam clover (18·9 md./acre), and cutting clover for fodder (12·9 md./acre).

(vii) *Phosphate fertilization of* Vicia sativa *and its after-effects on maize :* Like Hubam clover, *Vicia* did not respond significantly to the dressing of phosphate. Two cuttings, however, gave significantly higher yield (133·7 md./acre) than one treated *Vicia* cutting (102·8 md./acre). The after-effects of phosphate treated *Vicia* on maize yields were not significant.

(viii) *Comparative effect of different systems of rotations :* There are sixteen rotations of different intensities, including fallowing and green manuring which have run for five years. During the year under report potato and wheat amongst the several rotations gave significant results. The yield of potato in the rotation : *G. M.-wheat-fallow-potato-sugarcane* gave significantly higher yield (169·3 md./acre) than the rotation : *green manure-potato-maize-peas* (133·9 md./acre). Similarly the yield of wheat was highest (25·0 md./acre) under the rotation : *fallow-wheat-cotton-fallow-sugarcane*, followed by the rotation : *cotton-berseem-fallow-wheat* (24·0 md./acre). The lowest yield of 19·1 maunds was obtained from the rotation : *maize* and *cowpeas* (fodder)-*wheat-fallow-wheat.*

(ix) *Economics of different rotations, including green manuring :* The experiment was concluded and the economics of the rotation is reported as under :—

Rotation	Yield in md./acre		Expenditure per acre	Net profit per acre
	Maize	Wheat		
			Rs.	Rs.
A. Maize-fallow	6·3	—	133·0	—69·6
B. Fallow-wheat	—	18·3	161·0	240·0
C. Fallow-wheat manured with ammonium sulphate 20 lb. N/acre.	—	21·2	181·0	270·0
D. Maize-wheat manured with F. Y. M. at 10 tons/acre	8·3	15·9	326·0	97·0
E. Maize-peas	8·3	—	208·0	77·0
F. Green manure-wheat	—	20·9	218·0	221·0
G. Cowpeas-wheat	—	17·1	223·0	217·0
H. Maize—G. M. (in alternate rows)-wheat	5·7	14·9	300·0	95·0
'F' test	Sig.	Sig.	—	Sig.
S. Em.	±0·665	±1·31	—	±39·36
C. D. (5 per cent)	2·00	3·81	—	109·10

Green manure-wheat gave a net return of Rs. 221·0 per acre, while *maize-wheat* Rs. 97·0 ; *fallow-wheat* Rs. 240·0 ; *maize-peas* Rs. 77·0 and *cowpeas-wheat* Rs. 217 per acre. Green manuring was thus found economical as compared to double cropping like maize-wheat, maize-peas and cowpeas-wheat. Top dressing wheat with 20-lb. N in the *fallow-wheat* rotation gave maximum net profit of Rs. 270 per acre.

2. *Field crops section*

(i) *Response curve of nitrogen with N.P. wheat varieties :* The experiment was modified during the year under report. Fertilizer treatments were : 'no fertilizer' 60 lb. P_2O_5, 20 lb. N, 40 lb. N, 80 lb. N and 80 lb. N+60 lb. P_2O_5 and their responses to the fertilizers on five varieties of N. P. wheat 710, 718, 720, 792 and 799 were recorded as follows :

Variety	Yield in maund per acre — Fertilizer treatment per acre					Average
	No manure	60 lb. P_2O_5	20 lb. N	40 lb. N	80 lb. N	80 lb. N+60 lb. P_2O_5	
N.P. 710	25·7	24·9	30·2	31·3	28·1	31·2	28·6
„ 718	32·5	29·7	35·0	39·0	34·8	39·0	35·2
„ 720	32·5	34·4	41·2	37·5	35·1	33·0	35·7
„ 792	27·3	28·5	24·9	29·2	26·9	31·0	28·0
„ 799	26·9	26·5	24·8	33·5	29·7	29·4	28·0
Average	29·0	28·8	31·5	34·2	30·8	33·0	..

	'F' test	S. Em.	C. D. (5%)
Varieties	Sig.	±1·33	3·98
Manures	Sig.	±0·70	1·96
Varieties × Manures	Sig.	±2·26	6·33

The results indicated that N. P. 720 and N. P. 718 were equal (35·7 and 35·2 md./acre) in grain yield and significantly superior to N. P. 710, N. P. 792 and N. P. 799 (28·6, 28·0 and 28·4 md./acre). Of the fertilizer treatments, 40 lb. N. gave highest yield (34·2 md./acre) followed by 80 lb. N+60 lb. P_2O_5 (33·0 md./acre). Regarding response of varieties to nitrogen, N.P. 710, N. P. 792 and N. P. 799 did not show significant differences; N. P. 718 and N. P. 720 showed significant response to fertilization.

(ii) *Effect of 'soil need' type fertilizer on wheat :* As reported last year, this imported complete fertilizer (NPK) was tested against equivalent doses of N, NP and NPK, applied as ammonium sulphate, superphosphate and potassium sulphate. The differences due to the treatments over the control were not significant.

(iii) *Optimum time of application of various nitrogenous fertilizers to wheat :* Like last year, there were no significant differences amongst ammonium nitrate, ammonium sulphate, chilean nitrate and urea. Application of nitrogen half at four weeks and half at eight weeks after sowing indicated best results.

(iv) *Optimum time of application of F. Y. M. to wheat :* Results of this experiment also were similar to those obtained last year. Time of application of F. Y. M., viz. three months, two months, one month and one week before sowing wheat, did not show significant effect on the yield of wheat (27·1 to 28·6 md./acre), but the indications were in favour of three months, applications.

(v) *Effect of different sources of phosphate on berseem :* The experiment was conducted in collaboration with the Chemistry Division. Superphosphate alone and in combination with rock phosphate or Trichy nodules gave better results (412·2 to 484·3 md./acre) than bone meal, rock phosphate and Trichy nodule (301·7 to 399·5 md./acre).

(vi) *Fertilizer value of dicalcium phosphate :* This experiment was also conducted in collaboration with the Chemistry Division. The treatments were nitrogen 40 lb. N+P as super (80 lb. P_2O_5) and N+P as dicalcium phosphate (80 lb. P_2O_5). Nitrogen alone gave 23·2 md./acre as against 16·1 md./acre from the control. In the presence of nitrogen, dicalcium phosphate and superphosphate gave extra response of 1·0 and 1·5 md./acre. The difference was not significant.

(vii) *Cultivation*-cum-*manurial experiment in a rotation of maize-berseem-fallow-wheat :* The trend of the results this year were the same as last year. Deep ploughing with tractor gave slightly better yields of maize (12·2 md./acre) than shallow ploughing with bullocks (10·1 to 11·2 md./acre) due perhaps to greater storage of water. The differences were, however, not significant.

(viii) *Cultural*-cum-*manurial experiment on groundnut and Pigeon Pea :* With pigeon pea, like last year, deep ploughing with tractor did not show significant results (9·0 md./acre) over shallow ploughing with bullocks (8·1 to 8·7 md./acre). A spacing of 2½ ft. between rows, however, gave significantly higher yield (9·6 md./acre) than the spacing of 1½ ft. (7·6 md./acre). Further, broadcast application of fertilizer proved (9·0 md./acre) significantly superior to placement in rows (8·1 md./acre). The groundnut crop again failed due to fungus diseases.

(ix) *Spacing*-cum-*manurial experiment on* bajra : The experiment was conducted under rainfed conditions. Spacing of 9, 12 and 15 inches between rows did not show significant differences (12·1 to 12·7 md./acre). Similarly nitrogen levels 20, 40 and 60 lb./acre had no significant effect on the yield of *bajra*, but the trend was in favour of higher levels (10·8 to 13·8 md./acre) of nitrogen.

(x) *Varietal trial with wheat :* Twenty-four N. P. varieties of wheat were tested together with Punjab C. 591. The three high yielding varieties were N. P. 770, N. P. 111 and N. P. 775 (27·5, 27·5 and 26·8 md./acre respectively). Last year N. P. 792 gave the highest yield and this was followed by N. P. 710, N. P. 797 and Pb. C. 591.

(xi) *Plot carrying capacity of some pasture grasses* : Grazings were done on Rhodes grass, *anjan* (*Cenchrus* sp.) and *apang* (*Dichanthium annulatum*) grasses to determine the carrying capacity of these grasses. The carrying capacities of these grasses were 0·76, 0·775 and 0·594 animal per acre respectively under rainfed conditions.

(xii) *Fertilizer-cum-cutting trials with Rhodes and Blue Panic grasses :* The results are given in the following table :—

Particulars	Yield of Green fodder in md./ acre						
	Doses of nitrogen lb./acre				Intervals of cutting in days		
	0	40	80	120	20	30	40
Rhodes grass	235·5	324·7	391·6	466 4	327·6	355·6	379·9
S. Em.		±14·50				+12·57	
'F' test		Significant				Significant	
C. D. at 5 per cent . . .		42·53				36·86	
Blue Panic grass . . .	148·9	162·6	173·1	187·3	150·0	164·0	189·4
S. Em.		±3·53				+3·06	
'F' test		Significant				Significant	
C. D. at 5 per cent . . .		10·36				8·98	

With longer interval, significantly higher yields of forage were obtained (327·6 to 379·9 md./acre for Rhodes grass and 150·0 to 189·4 md./acre for Blue Panic). The effect of nitrogen was significant on both the grasses. With increasing doses 0, 40, 80 and 120 lb.N/acre, the yields increased significantly (235·5 to 466·4 md./acre for Rhodes grass and 148·9 to 187·3 md./acre for Blue Panic).

(xiii) *Grass scheme (I. C. A. R.) :* During the year under report 167 grasses collected, were tested along with the material collected previously. In yield trials, *Setaria sphaceluta*, *Brachiaria brizantha* and *Chloris gayana* showed promise under irrigated conditions, while *Chloris gayana* (giant Rhodes) and *Urochloa mosambicensis* were found high yielding under rainfed conditions. Co-ordinated testing for adaptability of grasses and legumes were carried out at 15 centres in the country. The crude protein content was highest in *Digitaria eriantha* amongst grasses and *Phaseolus lathyroides* amongst legumes.

(xiv) *Oilseed scheme (I. C. O. C.):* Out of 15 varieties of sesamum, strain 'S', evolved in this Institute showed best performance. Similarly 15 varieties of linseed from different States were tested. As there was no rust this year, T. 477 (U. P.) gave highest yield. Sesamum also showed significant responses to nitrogen doses.

3. *Vegetable and commercial crops section*

(i) *Manurial experiment on tobacco:* The experiment includes three levels each of N, P_2O_5 and K_2O, at 0, 40 and 80 lbs./acre. The yield of cured leaves of N. P. 18 showed significant responses to nitrogen (483·2 to 634·1 lb./acre) and P_2O_5 (464·9 to 656·9 lb./acre). The effect of potash was not significant.

(ii) *Manurial-cum-varietal trial on sugarcane:* Results obtained were similar to those got last year. The results are summarised as under:—

Varieties—	Yield of cane in md./acre
Co· 647	793·8
B. O. 11	732·9
Co. 659	724·7
Co. 739	699·3
Co. 797	692·9
Co. 312	612·5
'F' test	Not significant.
S. Em.	±54·04
Nitrogen levels—	
No manure	665·3
Amm. sulphate 40 lb. N	692·5
" " 80 lb. N.	719·3
" " 120 lb. N.	746·2
'F' test	Significant.
C. D. (5 per cent)	31·88

Nitrogen levels 40, 80 and 120 lb./acre showed significant effects (690·5 to 746·2 md./acre) over the control (665·3 md./acre). Among the varieties, Co. 647 gave highest yield of 793·8 md./acre followed by B.O-11 (732·9 md./acre), Co. 659 (724·7 md./acre), Co. 739 (699·3 md./acre), Co. 797 (692·9 md./acre) and Co. 312 (612·5 md./acre). The differences amongst the varieties, however, were not significant.

(iii) *Manurial experiment on cauliflower:* The experiment was started during the year under report. Three levels of nitrogen 0, 60 and 120 lb., three of P_2O_5: 0, 40 and 80 lb. and three of M_0O_5: 0, 1 and 2 lb. were studied on cauliflower, 'Snowball'. The effects of nitrogen and M_0O_5 were not significant. Responses to phosphate levels were significant (169·0 and 181·4 md./acre as against 121·1 md./acre for the control).

(iv) *Cultural-cum-manurial experiment on potato and carrot:* Unlike last year, shallow cultivation gave significantly higher yield of potato (361·4 md./acre) than deep cultivation with tractor (289·4 md./acre). Broadcast application of fertilizer gave significantly higher yield (340·8 md./acre) than the placement method (306·0 md./acre). Balanced manuring with NPK showed significantly higher yield than the control or NP treatment. The optimum dose was found to be 80-80-40. The interaction between cultivation treatment and mode of application of fertilizer was also found to be significant. Shallow cultivation with soil inversion bullock drawn plough and broadcast method of applying fertilizer gave significant result.

With carrots, cultivation treatments did not show significant effect. Differences among the other treatments were also not significant.

(v) *Cultural-cum-manurial experiment on cotton :* The results were similar as reported last year. Deep and shallow ploughings did not show significant differences. In this crop too, broadcast method of application of manure and fertilizers gave significant effect over placement.

(vi) *Cultural-cum-fertilizer experiment on tomato :* In the new experiment the treatments were 3 levels of nitrogen : 30, 60 and 90 lb./acre ; 3 levels of P_2O_5 : 20, 40 and 60 lb./acre and time of application of nitrogen. A summary of results obtained from two crops is given below :—

	Yield of 'Meeruti' tomato in maunds/acre	
	I crop	II crop
Nitrogen levels—		
Amm. sulphate 30 lb. N/acre	461·3	311·6
,, ,, 60 ,,	492·5	379·0
,, ,, 90 ,,	519·2	431·5
'F' test	Sig.	Sig.
C. D. (5 per cent)	26·25	23·7
Levels of P_2O_5—		
Super 20 lb. P_2O_5/acre	471·6	332·5
,, 40 ,,	497·7	370·6
,, 60 ,,	504·0	426·0
'F' test	Not sig.	Sig.
S. Em.	±8·37	..
C. D. (5 per cent)	—	23·71
Time of application of N.—		
Full dose at transplanting	483·1	371·2
Half at transplanting and half after 6 weeks	473·6	366·7
⅓ at transplanting, ⅓ after 6 weeks and ⅓ at flowering.	493·5	391·2
'F' test	Not sig.	Not sig.
S. Em.	+8·37	+7·23
No manure (control)	447·8	310·3

A basal dose of F. Y. M. at 10 tons per acre was applied to all plots before transplanting.

In the first crop, application of 90 lb. N/acre showed an increase of 71·4 maunds of tomato per acre over the no fertilizer control. The effects of phosphate was not significant and so also of the time application of nitrogen.

(vii) *Sugarcane analysis in relation to temperature :* Maximum yield of cane was obtained in mid-March planted crop this year as compared to mid-February planting in the previous years.

(viii) *Sugarcane varietal trial :* Co. 998 showed best performance in the plant as well as in the ratoon crops. The next best performance was shown by Co. 957. In juice quality these varieties fared better than Co. 312, the standard variety of the locality.

(ix) *Vegetable growers' holdings :* To evaluate the economic production of 3-acre holdings on the basis of vegetable culture with different systems of manuring, four holdings were started with (i) F. Y. M., (ii) activated sludge, (iii) ½ F. Y. M. and ½ fertilizer and (iv) fertilizers at NPK levels of 250-125-62·5.

4. *Irrigation investigation Scheme*

(Second Five Year Plan)

(i) *Irrigation-cum-fertilizer experiment on wheat :* The experiment was concluded this year after it had run for four years. Number of irrigations, 1, 2 and 3 did not show significant differences (12·1 to 12·9 md./acre). 20 and 40 lb. N/acre gave significant response (13·1 to 14·4 md./acre) over the control (10·2 md./acre). Among the varieties, N. P. 710 and N. P. 775 were found significantly superior (13·1 to 13·6 md./acre) to N. P. 718 (11·0 md./acre).

(ii) *Irrigation-cum-fertilizer experiment on sugarcane :* In this experiment also irrigations given at intervals of 10, 15 and 20 days did not show significant differences in the yield of sugarcane (722·2 to 749·7 md./acre). Differences in other main effects, namely, nitrogen levels and depth of cultivation were also not significant.

(iii) *Studies on the relationship between cropping pattern and irrigation intensity:* The long term experiment was started under this scheme during the year under report. Cropping intensity varying from 100 to 200 per cent. and irrigation intensity from 45 to 185 per cent. have been included in the experiment.

(iv) *Studies on the relationship of delta and depth of irrigation and levels of nitrogen and seed rates on wheat :* In this new experiment deltas of irrigation: 12, 15 and 18 acre inches nitrogen levels 20, 40 and 60 lb./acre and seed rates 48, 64 and 80 lb./acre did not show significant differences among the various treatments.

(v) *Inter-relationship of delta and depth of irrigation and levels of nitrogen on potato :* The experiment was started under this scheme in *rabi* 1955-56. The main effects, viz. delta of irrigation : 20, 28 and 36 acre-inches, depth of irrigation : 2, 3 and 4 inches and nitrogen levels, 80, 120 and 160 lb./acre were significant. Summary of results is presented as under :—

—	Yield of Potato "Up-to-date" in md./acre
Delta of irrigation—	
20 inches	84·80
28 ,,	151·20
36 ,,	168·80
Depth of irrigation—	
2 inches	145·60
3 ,,	144·80
4 ,,	114·40
Nitrogen levels—	
Amm. sulphate 80 lb./acre	115·20
,, ,, 120 ,,	145·60
,, ,, 160 ,,	144·00
'F' test	Sig.
C. D. (5 per cent)	23 2
Interactions	Not significant.

Smaller depth of water applied frequently increased the tuber yield significantly.

(vi) *Studies on the relative efficiency of spray, flood and furrow irrigation on tobacco :* In this new experiment the irrigation by spraying at 0·75 and 1 acre-inch resulted in the penetration of water only within first foot of soil, but when the rate was increased to 1·25 acre-inches, the water penetrated deeper than one foot of the soil layer.

5. *Weed Control Investigation Scheme*

(Second Five Year Plan)

(i) *Weedicide-cum-cultural experiment on baru (sorghum halepense) :* As reported last year, TCA and CMU were tried against digging with spade and deep and shallow ploughings for the control of *baru*, a perennial weed found in cultivated area. CMU and digging treatments markedly reduced the degree of weed infestation. *Bajra* was sown to study the after-effects of the cultural operations and weedicides. The CMU treated plots gave higher yield of *bajra* which may perhaps be due to no ill-effects of this soil sterilent, when applied in optimum doses.

(ii) *Weed control experiment on wheat:* The experiment was started under the scheme during the year under report to test the relative effectiveness of post- and pre-emergence use of 2, 4-D in conjunction with cultural practices for controlling weeds in wheat. Although there was an indication of the reduction of the stand of weeds due to pre-emergence application of 2, 4-D, the magnitude was very small. Post-emergence application of 2, 4-D had no adverse effect on the stand and tillering of the crop, but it was effective in controlling weeds, especially the broad leaved ones. In the post-harvest studies, a marked reduction in the population of *Heliotropium* sp. in the 2, 4-D treated plots was observed. In regard to the yield of wheat, the differences due to treatments were not significant.

(iii) *Weed control experiment on peas:* This experiment was also started in *rabi* 1955-56 under the scheme to test the relative effectiveness of TCA and 2, 4-D in conjunction with hoeing and weeding for controlling weeds in peas. The pre-emergence application of TCA had no effect on the population of weeds, but post-emergence application of 2, 4-D significantly reduced the weeds. The effect of treatments on the yield of peas was not significant.

6. *Agricultural Extension Scheme*

(Second Five Year Plan)

Eight post-graduate students were admitted for training in Agricultural Extension. In the Intensive Cultivation Scheme, extension work through demonstration, was continued in the 19 villages of the Delhi State. The total number of field demonstrations (including 250 on fertilizers) was 777, as against 696 in 1954-55. The area saturated with improved wheat variety N. P. 718, was 2,099 acres. Area roqued to maintain purity of seeds was 469 acres. The results of demonstration with improved varieties have shown increase in yields in respect of wheat N.P. 718, barley N. P. 13, gram N.P. 58 and *bajra* T. 55 over the local varieties. All villages under the scheme have been surveyed and maps delineating different soil types were completed. Reports on soils collected so far have been prepared for the use of farmers. Fuel gas plants have been installed in six villages and these are working satisfactorily. Total quantity of fertilizers sold was 575 maunds. Two hundred and forty fruit plants were supplied to the farmers.

7. *Fertilizer Use Project—*

During 1954-55, experiments conducted on wheat in the Community Projects and Complex Trial Centres were 895 and 55 respectively. The total number of such experiments conducted on paddy during 1955-56 were 779 and 69 respectively. With wheat, the responses were 2·56 and 4·87 maunds with 20 and 40 lb. nitrogen/acre and 2·36 and 3·58 maunds extra outturn with similar doses of P_2O_5. With paddy, the average responses to 20 and 40 lb. N/acre were 3·66 and 6·00 maunds while P_2O_5 responses at the same levels were 1·89 and 3·05 maunds respectively. The nitrogen response was shown on all the 20 soil types and P_2O_5 response on two-thirds of the soils.

A summary of three years' results on paddy is as under :—

(*a*) *Response to levels of nitrogen :* The responses at 20 and 40 lb. N levels were as follows :—

Response to	Yield in maunds per acre									Mean for three years
	1953-54			1954-55			1955-56			
	Cultivators' fields	Complex expt.	Mean	Cultivators' fields	Complex expt.	Mean	Cultivators' field	Complex expt.	Mean	
20 lb. N . . .	2·59	3·35	2·84	3·15	2·22	2·86	4 32	2·50	3·21	2·99
	(371)	(189)	(560)	(506)	(223)	(729)	(450)	(252)	(802)	(2091)
40 lb. N . . .	4·89	5·36	5·05	4·24	4·15	4·21	7·29	3 52	6·00	4·83
	(371)	(189)	(560)	(526)	(223)	(729)	(450)	(252)	(702)	(2091)

NOTE.—Figures in parentheses denote number of experiments.

The application of nitrogen gave high responses throughout the period. The mean responses for 20 and 40 lb. doses of nitrogen are 2·99 and 4·33 mds. per acre. Thus one ton of ammonium sulphate applied at the rate of 20 lb. per acre over 22 acres gave extra yield of 2·34 tons and when applied over half the area at the rate of 40 lb. N/acre the extra yield of every ton of fertilizer was 1·90 tons of paddy.

(*b*) *Response to levels of phosphate:* The response to phoshpate at 20 and 40 lbs. levels are given below :—

Response to	Yield in maunds per acre									Mean for three years
	1953-54			1954-55			1955-56			
	Cultivators' fields	Complex expt.	Mean	Cultivators' fields	Complex expt.	Mean	Cultivators' fields	Complex expt.	Mean	
20 lb. P_2O_5 . . .	1·56	2·65	2·16	1·66	1·67	1·66	2·25	1·49	1·89	1·88
	(154)	(189)	(343)	(133)	(297)	(430)	(348)	(306)	(654)	(1427)
40 lb. P_2O_5 . . .	2·66	3·83	3·30	2·60	2·37	2·44	3·23	2·84	3·05	2·92
	(154)	(189)	(343)	(133)	(297)	(430)	(348)	(306)	(654)	(1427)

NOTE.—Figures in parentheses denote number of experiments.

The phosphate application showed response at most of the centres. The response with phosphate, in general, was less than the response with nitrogen. The mean responses for 20 and 40 lb. P_2O_5/acre are 1·88 and 2·92 md./acre. Thus every ton of single superphosphate applied over eighteen acres at the rate of 20 lb. P_2O_5/acre resulted in extra yield of 1·21 tons. The extra yield for every ton applied at the rate of 40 lb. P_2O_5/acre over nine acres gave 0·94 tons of paddy only.

8. *Agronomic experiments in relation to wheat rusts*

The experiments were concluded during 1955-56. As in the previous years, agronomic experiments were conducted both at the I.A.R.I., New Delhi and B.S.S. Pusa. The observations were taken in collabortaion with the Mycology Division. At New Delhi, like last year, the intensity of rust was maximum in plots treated with high dose of nitrogen (60 lb./acre and above). In the mixed crop of wheat. gram and linseed, the intensity of yellow rust was found to be appreciably lower than in the pure crop of wheat. Plots sown on the 1st December, 1955 showed slightly heavier infection of yellow rust than others. The effect of micronutrients in relation to incidence of rust was studied during the year under report for the first time. In treatment NPK+zinc spray, it was observed that the intensity of rust infection was appreciably less in all the replications than in other treatments. At Pusa, heavier infection of rust was observed in wheat in plots green manured followed by cereals, than the plots under purely cereal rotation.

9. *Agronomic experiments at Pusa*

(i) *Permanent manurial and rotation experiments :* The results are given below :—

Plot No.	Treatment per acre	Yield of grain per plot in lb. (¼ acre plot.)					
		A series			B series		
		Maize	Barley	Wheat	Maize	Arhar	Barley
1	No manure (check No. 1) . . .	44·9	67·8	—	12 6	112·2	—
2	F. Y. M. 4,000 lb.	102 3	131·3	—	38·7	260·2	—
3	F. Y. M. 8,000 lb.	106·0	259·3	—	58 0	285·1	—
4	F. Y. M. 4,000 lb. *plus* rape cake 20 lb. N.	104·7	248·6	—	59·8	257·7	—
5	Rape cake 40 lb. N	74·7	213·1	—	59·3	180·5	—
6	Amm. sulphate 40 lb. N . . .	21·2	128·1	—	18·7	104·6	—
7	Pot. sulp. 50 lb. K_2O . . .	14·0	102·0	—	11·9	93·4	—
8	Super 80 lb. P_2O_5	20·0	314·2	—	28·6	260·2	—
9	Super 80 lb. P_2O_5 + pot. sulp. 50 lb. K_2O	28·4	287·3	—	17·5	209·2	—
10	Am. sulp 40 lb. N + super. 80 lb. P_2O_5 + pot sulp. 50 lb K_2O.	15·0	390·6	—	10·3	216·6	—
11	Am. sulp. 40 lb. N + super 80 lb. P_2O_5	4·3	424·0	—	1·9	171·8	—

Plot No	Treatment per acre	Yield of grain per plot in lb (¼ acre plot)					
		A series			B series		
		Maize	Barley	Wheat	Maize	Arhar	Barley
12	G M in conjunction with cereal rotation	—	—	64·6	—	—	101·1
13	No manure (check No 2)	Failed	108·7	—	Failed	2·4	—
14	Am sulp 40 lb N pot sulp 50 lb K_2O	1·0	116·2	—	Failed	1·0	—
15	Effect of G M and legumes in rotation	—	204·0	—	Failed	10·0	—
16	As in plot No 15 super 80 lb P_2O_5 to G M	—	80·9	—	Failed	Failed	—
17	No legume and no G M (cereal rotation)	Failed	—	28·8	Failed	Failed	44·3
18	No manure (check No. 3)	Failed	75·2	—	Failed	Failed	—

Maize yields were affected by continuous rains and water-logging. With barley good responses were shown by NP, NPK and G. M. plus super treatments. The *arhar* crop was also affected by heavy rains and water-logging in some of the plots. Good yields were obtained from plots treated with F. Y. M. and superphosphate.

(ii) *New Manurial experiment:* The following results were obtained :—

Treatment per acre	Yield of grain in Md acre	
	Maize	Gram
A. No manure	f	13·07
B. F.Y.M. 40 lb. N	a	15·70
C. Rape cake 40 lb. N	i	12·83
D. Am. sulp. 40 lb. N	l	13·03
E. Pot. sulp. 50 lb. K_2O	e	11·19
F. Super 80 lb. P_2O_5	d	14·92
G. Super 80 lb. P_2O_5 + pot. sulp. 50 lb. K_2O		14·68
H. Am. sulp. 40 lb. N + super 80 lb. P_2O_5 + pot. sulp. 50 lb. K_2O		12·69
I. Am. sulp. 40 lb. N + super 80 lb. P_2O_5		13·56
J. Am. sulp. 40 lb. N + pot. sulp. 50 lb. K_2O		11·81
'F' test		Significant at 1%
S. Em		±0·714
C. D. at 5 per cent		2·01

The maize crop failed due to water-logging. With grain, F. Y. M., P, PK and NP gave high yields,

III. *Seed Distribution*

The following seeds of the improved varieties of crops were distributed during 1955-56 :—

Crop	Quantity (md.)
Wheat	1244·00
Oats	18·50
Barley	9·14
Gram	4·00
Peas	45·95
Berseem	5·26
Paddy	3·31
Maize	20·89
Other crops	11·61
Sugarcane setts	1686·50
Grasses and legumes	429·00 seed samples.
Kudzu vine	1500 crowns.

IV. *Farm Economics*

(i) *Farm costing—Crop production :* The cost of production of principal crops grown on the farm during 1954-55 is given below :—

Block	Crop	Area (ac.)	Yield md./ac.	Cost of production	
				Per ac.	Per md.
				Rs.	Rs.
I. Seed Multiplication . .	Wheat . . .	18·85	28 51	311·25	*10·42 (7·79)
II. Experimental .	Wheat . . .	61·79	19·72	372·47	*18·89 (13·92)
,,	Berseem (fodder) .	4·62	601·34	839 66	1·40
,,	Sugarcane . .	7·88	672 56	1,298·60	1·93
,,	Maize (grain) . .	11·74	13·43	483·38	* 35·99 (29·98)
III. Commercial . . .	*Jowar* (fodder) .	14·40	186·39	225·44	1·13
,,	Peas (grain) . .	10·80	18·83	214·32	† 11·38
IV. Feeds and fodder . .	*Jowar* (fodder) .	22·32	241·66	249·95	1·03
,,	Maize and Cowpea (fodder).	13·81	232·79	321·16	1·38
,,	Oats (grain) . .	45·52	21·00	255·38	*12·16 (10 06)

* The total cost of production has been charged to the main product.

† The total cost of production has been apportioned to the main and by-product.

The cost of crops in the experimental area was 70-80 per cent higher than in seed multiplication block of wheat. The yield of maize was relatively low and therefore the cost of production was very high. In other crops the cost of production was relatively remunerative in spite of high irrigation cost.

(ii) *Farm efficiency studies:* The cost of operation by tractor was worked out for the year 1954-55 and the figures are as follows :—

Tractor	Cost per hour (Rs)			Cost per acre (Rs)		
	Ploughing	Discing	Grubbing	Ploughing	Discing	Grubbing
T. D. 9 . . .	5 96	5 89	6 13	10 64	4 57	5·11
D4 (workshop) . . .	6 67	6 66	6 27	13 08	4 96	9 95
D4 (20)	5 61	5·52	5·10	8·37	3·54	5·10
D4 (10)	—	8 35	8·16	—	6·19	7·77
Farmall	—	5 66	6·14	—	4·64	4·10

Relatively the cost of operations with D 4(20) and Farmall tractors were lower than with other tractors maintained at the Institute.

(iii) *Agro-economic survey:* An economic appraisal of the Intensive Cultivation Scheme was taken up to assess in general the benefits accruing to the cultivators as a result of introduction of improved varieties of seeds, implements, cultural practices, etc.

It was found that wheat N.P. 718 not only showed a technical improvement, but an economic improvement as well in the sense that it resulted in increased production at a lower cost and did not involve any capital problem, which is a serious consideration in the case of under-developed countries. The average cost of production of N.P. 718 was lower by Rs. 3-9-4 due to the average higher yield by 3·46 md. per acre as compared to the local variety of wheat.

V. *Cattle breeding and Management*

(i) *General:* The strength of the Sahiwal herd on 30th June, 1956 was 78 head as against 64 at the close of the last year. The herd consisted of 31 cows, 2 stud bulls, 14 young male stock, 16 young female stock, 6 male calves and 9 female calves. The animals, in general, maintained good health.

(ii) *Milk yield :* The wet and overall averages during 1955-56 were 23·5 and 15·5 lb. respectively, as against 23·2 and 15·9 lb. recorded last year. Out of 18 cows which completed their lactations, two did over 9,000 lb., three over 8,000 lb., seven over 7,000 lb. milk yield per lactation period of 306 days.

(iii) *Calf rearing :* Fourteen male and nine female calves were born during the year. Their average birth weights were 55·0 and 50·6 lb. respectively. There were four mortalities among the pail-fed calves.

A new system of rearing pail-fed calves was introduced with a view to reducing the rearing cost. The calves after birth are now given standardized milk containing 3·5 per cent butter fat, upto the age of one month and thereafter put to skimmed milk upto the age of six months in the case of male and eight months in the case of female calves. These calves showed normal growth under the new system of feeding. The average growth rate of male and female calves was 1·1 lb. per head per day.

(iv) *Early maturity experiments :* The performance of the early maturity heifers was 6,508 lb. in the first lactation as against 7,057 lb. for the second calvers and 6,321·4 lb. for the adults in the same lactation. Average age at first calving of the heifers was 2 years, 6 months and 14 days.

(v) *Sale of cattle :* One young bull was sold during the year at Rs. 900.

VI. *Key Village Scheme*

Three Key Village Centres with Nangloi as headquarters in the Delhi State were set up for the improvement of Hariana cattle and Murrah buffaloes. Castration of scrub bulls was undertaken in the 19 villages under the Intensive Cultivation Scheme. Necessary advice with regard to feeding and treatment of diseased cattle was given to the farmers.

VII. *Programme of work for 1956-57*

1. *Soil fertility section :*
   - (i) Building up of soil fertility through organic manures and inorganic fertilizers.
   - (ii) Building up of soil fertility through phosphate manuring of legumes.
   - (iii) Building up of soil fertility through crop rotations.
   - (iv) Experiments on 6-acre holdings.

2. *Field crops section :*

(i) Response to manures and fertilizers.

(ii) Cultural experiments.

(iii) Varietal trials.

(iv) Agronomic experiments on grasses and legumes for forage and pasturage.

(v) Grass land scheme (I.C.A.R.).

(vi) Oilseed scheme (I.C.O.C.).

3. *Vegetable and commercial crops section :*

(i) Response to manures and fertilizers.

(ii) Cultural experiments.

(iii) Varietal trial.

(iv) Vegetable growers' 3-acre holdings.

4. *Farm and cattle section :*

(i) Line breeding and selection for improvement in milk yield.

(ii) Feeding of stock on balanced ration for optimum growth, early maturity and high milk yield.

(iii) Rearing of pail-fed calves on skim milk.

(iv) Key Village Scheme.

5. *Projects under Second Five Year Plan :*

(i) Irrigation investigation scheme.

(ii) Weed control investigation scheme.

(iii) Agricultural extension scheme.

(iv) Tissue test and spray fertilization scheme.

6. *Agronomic experiments at B.S.S., Pusa :*

(i) Permanent manurial and rotation experiments.

(ii) New manurial experiments.

AGRICULTURAL RESEARCH SUB-STATION, KARNAL.

The total area of the Sub-station increased from 180·12 to 291·75 acres with the re-organization of the National Dairy Research Institute, Agricultural Research Sub-station and Sugarcane Sub-station, Karnal. The areas cropped in the *kharif* and *rabi* seasons were 112·52 and 215·76 acres respectively.

The main activities of the Sub-station were to (i) carry out large-scale field experiments on different aspects of agronomic research, (ii) multiply and distribute seeds of improved strains of field crops and (iii) render assistance to the different Divisions of the Institute in carrying out their field experiments.

I. *Response of crops to seasons*

The total rainfall from 1st June, 1955 to 31st May, 1956 amounted to 37·10 inches as against 28·34 and 36·18 inches recorded during the corresponding periods of 1954-55 and 1953-54 respectively. The rainfall was much above the normal which is 25·89 inches. Heavy showers in September and October accompanied with high wind caused severe damage to the standing *kharif* crops in general. The *rabi* crops, in general, suffered from droughty conditions during the months of December, January and February.

The yields of the principal crops grown on the farm are given below. Severe infestation of *baru* (*Sorghum halepense*) grass at the new site of the farm was specially responsible for reduced yields :—

Crop	Area (acres)	Yield per acre (Mds.)	Remarks
Grain—			
Paddy	27·27	16·7*	*Low yield due to excessive rains and submerged condition of the crop.
Cotton	6·00	17·6	
Wheat	120·09	10·5**	** Low yield due to inadequate irrigation supply, failure of winter rains and infestation of *baru* grass in the new area.
Barley	8·50	15·4	
Oat	14·30	16·2	
Gram	18·90	6·3***	*** Low yield due to failure of winter rains and infestation of *baru* grass in the new areas.
Pea	13·70	8·3***	
Fodder—			
Jowar	13·04	149·8	
Cowpea	3·80	202·9	
Maize and cowpea	1·00	251·0	
Berseem	5·00	430·6	

II. *Research projects*

1. *Manurial experiments*

(i) *Fertilizer value of ammonium chloride and ammonium sulphate-nitrate.*— This is the third year of the experiment. Three forms of nitrogenous fertilizers, namely, ammonium sulphate-nitrate, ammonium chloride and ammonium sulphate at 20 lb. and 40 lb. N were applied to paddy in *kharif* and wheat in *rabi* in two different experiments. In the case of paddy, all the manurial treatments were significantly superior to 'no manure'. Also ammonium chloride at 40 lb. N (26·58 md./acre) was significantly superior to ammonium sulphate-nitrate both at 40 lb. N (20·88 md./acre) and 20 lb. N (20·72 md./acre), and ammonium sulphate at 40 lb. N (22·54 md./acre).

In the case of wheat, all other manurial treatments, except ammonium sulphate at 20 lb. N (12·90 md./acre) were significantly superior to 'no manure' (10·77 md./acre). The highest yield of 16·25 maunds per acre was given by ammonium chloride at 20 lb. N.

(ii) *Soaking of paddy seedlings in nutrient solutions.*— Paddy seedlings dipped in 2·5 per cent solutions of ammonium sulphate, ammonium nitrate, urea and 5 per cent solutions of superphosphate and ammonium phosphate as well as 2·5 per cent solution of ammonium sulphate and 5 per cent superphosphate and 50 per cent F.Y.M. soil emulsion did not produce significantly higher yields than 'no manure'.

(iii) *Levels and sources of nitrogen and levels of phosphate on non-acid soils.*—Three forms of nitrogen, viz. ammonium sulphate, ammonium nitrate and urea at three levels of nitrogen and phosphate at 0, 20 and 40 lb. respectively along with three extra combinations— 60 lb. N plus 40 lb. P_2O_5, 40 lb. N plus 80 lb. P_2O_5 and 60 lb. N plus 80 lb. P_2O_5 were included in the experiment on paddy in *kharif* and wheat in *rabi* in separate plots. In the case of paddy, 40 lb. N(19·88 md./acre) and 20 lb. N(18·13 md./acre) were at par between themselves and were significantly superior to 0 lb. N (15·72 md./acre). The highest yield of 22·99 maunds per acre was obtained from the treatment combination of 60 lb. N plus 40 lb. P_2O_5. Forms of nitrogen and phosphate effects were not significant.

In wheat, 40 lb. N (20·86 md./acre) was significantly superior to 20 lb. N (16·95 md./acre) which, in turn, was significantly superior to 0 lb. N(13·39 md./acre). 40 lb. P_2O_5 (19·27 md./acre) was at par with 20 lb. P_2O_5 (17·26 md./acre) and both were significantly superior to 0 lb. P_2O_5 (14·67 md./acre). Sources of nitrogen and extra combinations did not produce significant differences.

(iv) *Varieties and fertilizers.*—Two improved paddy varieties, viz. N.P. 97 and N.P. 130, medium-fine varieties, were compared with local Jhona coarse variety. Ammonium sulphate and superphosphate treatments consisted of 0, 20 and 40 lb. N and P_2O_5 respectively. 40 lb. N (16·77 md./acre) was at par with 20 lb. N(15·90 md./acre) and both were significantly superior to 0 lb. N(8·30 md./acre). Phosphatic and varietal effects were not significant.

In the case of wheat, 40 lb. N (14·97 md./acre) was significantly superior to 20 lb. N(11·90 md./acre) which in turn was significantly superior to 0 lb. N(7·00 md./acre). 40 lb. P_2O_5 (13·30 md./acre) was at par with 20 lb. P_2O_5 (12·65 md./acre) and both were significantly superior to 0 lb. P_2O_5 (8·51 md./acre). Variety N.P. 718 (13·63 md./acre) was significantly superior to N.P. 710 (11·63 md./acre) which in turn gave significantly higher yield than 'Local' (9·20 md./acre).

(v) *Effect of artificial fertilizers in conjunction with organic manure :* F.Y.M. was applied to paddy at 0, 10 and 20 Cartloads per acre. Ammonium sulphate and superphosphate treatments consisted of 0, 20 and 40 lb. N and P_2O_5 respectively. Paddy results showed that 40 lb. N (10·96 md./acre) was at par with 20 lb. N (10·89 md./acre) and both were significantly superior to 0 lb. N(7·04 md./acre). Similarly both 20 cartloads (10·10 md./acre) and 10 cartloads (10·21md./acre) were significantly superior to 'no F.Y.M.' (8·57 md./acre). Phosphate effects were not significant.

With regard to wheat, 40 lb. N (27·40 md./acre) was significantly superior to 20 lb. N (21·88 md./acre) and this in turn gave significantly higher yield than 0 lb. N (15·72 md./acre). 20 cartloads (23·58 md./acre) and 10 cartloads (22·97 md./acre) were at par between themselves and both were significantly superior to 'no F.Y.M' (18·68 md./acre). 40 lb. P_2O_5(22·97 md./acre) was at par with 20 lb. P_2O_5 (22·64 md./acre) and both were significantly superior to 0 lb. P_2O_5 (19·40 md./acre).

(vi) *Time of application of fertilizers :* Two forms of nitrogenous fertilizers, viz. ammonium sulphate and urea at 30 lb. N were applied (i) before transplanting (ii) at transplanting (iii) at tillering and (iv) a week before flowering, to paddy. Superphosphate at 20 lb. P_2O_5 was applied as a basal dose to all the treatments. Due to heavy rains in the months of September and October, 1955, the crop remained submerged under water for about three weeks. This seemed to be responsible for producing non-significant differences among the treatments.

In wheat, the treatments comprised of three forms of nitrogen, viz. ammonium sulphate, ammonium nitrate and urea at 20 lb. N applied either at the time of sowing or at first irrigation. Forms of nitrogen did not show any significant differences. 20 lb. N(14·48 md./acre) produced significantly higher yield than 0 lb. N(10·16 md./acre.) Application of nitrogen at sowing (14·99 md./acre) gave significantly higher yield than that applied at first irrigation (13·94 md./acre).

(vii) *Placement of fertilizers :* In the case of paddy, the treatments consisted of two types of phosphate, viz. superphosphate and ammonium phosphate at two levels 20 lb. and 40 lb. P_2O_5 with four methods of application, viz. (i) broadcasting at puddling (ii) drilling at puddling (iii) dipping the seedlings in mud slush mixed with fertilizers at transplanting and (iv) pellets, a fortnight after transplanting. Nitrogen was equalised by ammonium sulphate to make up 30 lb. N. Due to heavy rains in the months of September and October, 1955, the crop remained submerged under water for about three weeks. This appeared to be responsible for producing non-significant differences among the treatments.

In wheat, three forms, viz. superphosphate, nitrophosphate and ammonium phosphate at twolevels 15 lb. and 30 lb. P_2O_5 as well as two methods of application, i.e. (i) broadcast and (ii) placement at $2\frac{1}{2}$ inches below seeds, were included.

A basal dressing of 30 lb. N was applied to all the treatments. Forms of phosphate did not exhibit any significant differences. There was no significant difference in yield due to broadcast and placement. 40 lb. P_2O_5 (20·85 md./acre) produced significantly superior yield to 20 lb. P_2O_5(17·79 md./acre) which in turn was superior to 0 lb. P_2O_5 (9·77 md./acre).

(viii) *Residual value of phosphate :* The treatments consisted of superphosphate at 0, 10, 20 and 40 lb. P_2O_5 with a basal dressing of 20 lb. N. Paddy was transplanted this year in the new site. Residual effects will be studied from the next year.

(ix) *NPK experiment :* Ammonium sulphate, superphosphate and sulphate of potash were applied to paddy at 0, 20 and 40 lb. each of N, P_2O_5 and K_2O respectively. 40 lb. N(15·22 md./acre) was at par with 20 lb. N(13·70) md /acre and both were significantly superior to 0 lb. N(9·89 md./acre). 0 lb K_2O (13·96 md./acre) was significantly superior to 40 lb. K_2O (12·17 md./acre) which was at par with 20 lb. K_2O (12·68 md./acre). Phosphate effects and interactions were not significant.

(x) *Paddy-wheat manurial experiment :* The experiment was conducted for four years. Three levels of N : 0, 30 and 60 lb., three of P_2O_5 : 0, 60 and 120 and two of K_2O : 0 and 80 lb. per acre were applied to (i) both the crops and (ii) to paddy only. The yield of paddy indicated significant differences due to nitrogen levels ; 60 lb.N yielded the highest (27·7 md./acre), followed by 30 lb. N (25·4 md./acre) and no nitrogen (23.7 md./acre). The response to P_2O_5 was not significant in the first two years only, thereafter 60 and 120 lb. P_2O_5 showed significant response over the no phosphate treatment. The interaction between N & P was significant. The effect of potash and other interactions were not significant. There was also no significant difference between yields when fertilizers were applied to both the crops and when applied to paddy only.

With wheat, the effect of N only was significant. 60 lb. N gave an yield of 17·3 md./acre, against 16·0md. /acre with 30 lb.N and 14·7 md./acre under the no nitrogen treatment. The effects of phosphate and potash were not significant. Application of fertilizers to both the crops showed significant difference over the application of fertilizers to paddy only. The fact that the interaction of NP on paddy yield was significant in the Karnal soil is of value, considering the usually high available P_2O_5 content of the Karnal soil. It also shows that yields of wheat and paddy can be maintained by direct application of fertilizers to both the crops.

(xi) *Green manuring paddy in conjunction with fertilizers :* The experiment was concluded after it had run for three years. The G. M. treatments were : No G.M., G.M. with *dhaincha* and G.M. with *dhaincha* +60 lb. P_2O_5/acre. The levels of nitrogen as ammonium sulphate were : 0, 20 and 40 lb. acre. The response to G.M. in conjunction with phosphate (40·2 md./acre) and G.M. alone (39·4 md./acre) gave significant difference over the No G.M. treatment (31·5 md./acre). The effect of phosphate in the phosphate rich soil of Karnal was not significant. In regard to

the nitrogen levels, 40 lb. (38·5 md./acre) and 20 lb. (37·6 md./acre) showed significant response over the no nitrogen treatment (35·0 md./acre). The interaction between G.M. and nitrogen doses was significant. The highest yield of paddy (40·8 md./acre) was obtained from the treatment G.M. in conjunction with phosphate and 40 lb. N/acre.

(xii) *Paddy nursery manurial experiment :* This experiment was also conducted for three years. The main plot treatments of nursery manuring were : 0, 1000 md. and 2,000 md. F.Y.M./acre and the subplot treatments of field manuring were : 0, 20, 40 lb. N/acre as ammonium sulphate and 20 and 40 lb. N/acre as F.Y.M. The effects of main plot treatments were not significant. In regard to the field manuring treatment, 40 lb. N/acre as ammonium sulphate gave significantly high yield (36·8 md./acre) over other treatments (32·1 to 34 md./acre). The interaction was not significant. The results show the beneficial effect of field manuring of paddy. Nursery manuring has not proved conducive to high yields.

2. *Varietal trials*

(i) *Wheat varietal trial :* Wheat varieties N.P. 718, N·P. 792, N.P. 797, N.P. 798, N.P. 799, C. 281 and C. 591 were tested for their yields both under 'irrigated' and 'barani' conditions. In the irrigated series, C. 591 (19·29 md./acre) was at par with N.P. 792 (18·61 md./acre) and significantly superior to C. 281 (17·04 md./acre), N.P. 797 (16·54 md./acre), N.P. 718(16·24 md./acre), N.P. 799(15·56 md./acre) and N.P. 798 (15·45 md./acre) which did not significantly differ among themselves. Due to failure of rains in the months of December, January and February, the growth of the crop under 'barani' series was severely affected resulting in very low yields. Hence the varietal differences were not significant.

(ii) *Linseed varietal trial :* Seven N.P. (R.R.) varieties of linseed, viz. 9, 37, 38, 45, 431, 439, 440 and K2 were included in the trial. Varieties N.P.(R.R.) 45 (9·97 md./acre), N.P. (R.R.) 9 (9·97 md./acre) and K. 2 (9·72 md./acre) were at par among themselves and significantly superior to the remaining varieties. Varieties N.P. (R.R.) 439 (7·98 md./acre), N.P.(R.R.) 431 (7·62 md./acre) and N.P. (R.R.) 440 (6·96 md./acre) did not differ among themselves and were significantly superior to N.P. (R.R.) 38 (4·83 md./acre) and N.P. (R.R.) 37 (4·82 md./acre) which were at par with each other.

(iii) *Early and mid-early paddy varietal trial :* 12 varieties of paddy, viz. N.P. 97, N.P. 125, N.P. 130, Jhona 349, Palman 246, CH. 10, CH. 41, CH. 42, CH. 43, CH. 45, and CH. 63 were tested for their yields. The varietal differences were significant. CH. 45 (21·48 md./acre) produced the highest yield. However, there were no significant differences among CH. 45, N.P. 130 (21·09 md./acre), CH. 54 (20·29 md./acre), N.P. 97(20·20 md./acre), CH. 42 (19·40 md./acre), CH. 41 (19·21 md./acre) and Jhona 349 (18·92 md./acre).

(iv) *Late paddy varietal trial :* Ten varieties, viz. N.P. 137, T.9, T.21, T.43, T.88, T.138, Z.31, EK.70, Basmati 370 and CH. 47 were included in the trial. The varietal differences were not significant.

(v) *Sorghum varietal trial :* The experiment was conducted for three years. The varieties tested were : J.C.20, J.C.21, J.C.100, J.C.263 (Punjab selections), C-10-2, Nandyal. Nilwa and Sundhia (Bombay selections) and local. Highest yield of green fodder was given by J.C. 20 (296·0 md./acre), followed by J.C.21 (284·0 md./acre), C-10-2 (282·9 md./acre), local (266·2 md./acre) and Nilwa (264·5 md./acre). Other Varities were low yielders (150·8 to 229·5 md./acre).

3. *Cultural experiments*

(i) *Tillage of wheat in conjunction with green manure and fertilizers :* The whole area was green manured with sunnhemp. 'Tractor ploughing' (17·72 md./acre) was significantly superior to 'Victory-cum-country ploughing' (15·32 md./acre). Among the fertilizers, 60 lb. N plus 80 lb. P_2O_5 plus 120 lb. K_2O (20·09 md./acre), 60 lb. N plus 80 lb. P_2O_5 (19·96 md./acre) and 60 lb. N(19·48 md./acre) were at par with one another, but were significantly superior to 80 lb. P_2O_5 (14·11 md./acre), 80 lb. P_2O_5 plus 120 lb. K_2O (12·66 md./acre) and 'no fertilizer' (12·83 md./acre), there being no significant differences among the latter three. The interaction was also found to be significant.

(ii) *Cultural experiment on paddy* The experiment was concluded after it had run for four years. Three methods of sowing paddy adopted were : (i) broadcasting at 40 seers/acre ; (ii) transplanting at 10 seers/acre ; and (iii) drilling at 20 seers/acre. Differences among the treatments were not significant. The yields due to the treatments were 26·5, 27·6 and 26·4 md./acre. With higher seed rates and simultaneous sowing in the field and nursery, drilling and broadcasting methods gave almost the same yield as obtained from the transplanted crop.

4. *Cultivators' holdings*

Long term experiments with revised cropping schemes on 6-acre holdings were started during the year under report to study how far they are self-sufficient in providing the requirements of five human beings and seven cattle.

5. *Seed supply*

The following quantities of seed of improved varieties of crop were distributed during the year :—

Paddy Md.	Cotton Md.	Cowpea Md.	Wheat Md.	Gram Md.	Pea Md.	Berseem Md.	Sugarcane Md.
80·82	0·50	3·70	1081·65	20·21	69·20	8·36	51·38

Programme of work for 1956-57

The work will be continued on the same lines mentioned in the report.

REPORT OF THE DIVISION OF BOTANY

(INCLUDING THE BOTANICAL SUBSTATION, PUSA)

(DR. S. M. SIKKA)

The researches conducted in the Division of Botany aim at gathering knowledge both fundamental and applied in nature, in the field of agricultural botany and its branches, such as plant genetics and breeding, cytogenetics crop physiology, plant introduction and others, with the object of evolving superior varieties of crop plants. Work on these lines continued in the main Division at New Delhi, under the five Sections, *viz.*, Plant Breeding and Genetics, Cytology and Cytogenetics, Crop Physiology, Plant Introduction and Systematic Botany, and Horticulture, and at the Botanical Sub-station, Pusa (Bihar) and the Central Vegetable Breeding Sub-station, Katrain (Kulu Valley). The Horticulture section will shortly be separated into a Division of Horticulture under the Institute. The wheat improvement work at Delhi and Simla was placed on a permanent footing; this work now includes breeding for resistance to the bunt diseases also. Steps have been taken to establish a wheat milling and baking laboratory on modern lines with the co-operation of the Indo-U.S. Technical Co-operation Mission. The scope of the project on hybrid maize was considerably widened under an I.C.A.R. scheme and this Division has been entrusted with its co ordination on an all-India regional basis. Under the Second Five Year Plan, a seed testing station, primarily devoted to vegetable seed testing, a strong unit for mutational research and a scheme for embryo-culture work came into operation. Work done under the research schemes financed by the I.C.A.R. and other bodies related to the following: improvement of some essential-oil-bearing spice plants, breeding for disease resistance in chilli, improvement of pasture grasses and legumes, physiological study of the effect of deficiencies of micronutrient elements in certain plants, and cytogenetical and physiological studies in some oil-yielding crops. During the year under report, a coordinated scheme for the improvement of watermelon and muskmelon was sanctioned by the I.C.A.R. The nucleus plant introduction organisation, set up in this Division in 1946 under an I.C.A.R. scheme, was expanded into a permanent, full-fledged, all-India organisation—the Plant Introduction and Exploration Organisation.

Collaborative work, mainly involving exchange of scientific information and plant material, was done as in previous years with research institutions in India and abroad; this included work relating to the catalogue of genetic stocks in wheat

in co-operation with the F.A.O. A large volume of advisory work was attended to and distribution of pure seeds of improved varieties of field and vegetable crops to growers was done on a considerable scale.

The results obtained in the main lines of work in progress during 1955-56 are given below.

Plant Breeding and Genetics

1. *Improvement of Indian wheats* (*Triticum* spp.)

(i) *Breeding rust resistant wheat varieties.*—The work is being done at Delhi and at the four sub-stations located at Pusa, Simla, Indore and Wellington; a fifth sub-station at Bhowali (U.P.) was set up during the year. The object is to breed varieties resistant to the several physiologic races of the three rusts and to the smut and bunt diseases; the other desirable characters, besides yield, which are sought to be incorporated include: suitability to early and late sowing, to irrigated and *barani* conditions, and to average and high levels of soil fertility, resistance to lodging and drought, and grain quality. The work at Simla is directed specially towards the improvement of hill wheats, at Indore the emphasis is laid on evolving disease resistant superior varieties of *T. durum* suitable for central and peninsular India, and at Wellington (Nilgiris) on the improvement of *T. dicoccum*. To this end, extensive breeding material was under careful study at the above experiment stations.

(a) *Intervarietal hybridisation in T. aestivum L.* (=*T. vulgare* Host)

Extensive hybridisation between suitable varieties of *T. aestivum* is being carried out with the object of effecting further improvement, with regard to yield, greater disease resistance, better ear and grain characters, etc., in N.P. wheat varieties, such as N.P. 710, N.P. 718, N.P. 775, which have already given excellent accounts of themselves. The donors of disease resistance and other desirable characters are: E. 671 (Cometa Klein), E. 957 (Frontiera), E. 581 (Kenya 184 P_2 A.I.F.) and N.P. 790. From these and other crosses, over 12,000 desirable single plant selections were made in the field, out of which over 1,000 were finally selected. A number of families, of hybrid origin, have reached an advanced stage at which they are now true-breeding in respect of rust resistance and other desirable agronomic characters.

(b) *Interspecific hybridisation*

With a view to incorporate into improved varieties genes for disease resistance from as diverse sources as possible, crosses made between *T. aestivum* on the one hand, and *T. durum* (E. 931, E. 2625, E 2158), *T. dicoccum* (E. 1928, I.C. 1057), and *T. pyramidale* (E. 2322), on the other, have been under study. An intensive back-cross programme is being followed; 1,037 single plant selections have been made from these progenies.

(c) *Rust resistance tests*

This work is being done in collaboration with the Division of Mycology and Plant Pathology.

About 900 foreign varieties were studied, both under natural and artificial conditions of rust infection. Of these, 117 varieties showed resistance to yellow rust, 34 to brown and 18 to black rust; 19 varieties were resistant to yellow and brown rusts, 6 to black and brown rusts and 3 to black and yellow rusts. Four varieties: E 2842 (Yaquie 53) and W. 207 (Bowie) from the U.S.A., W. 219 (Tremez Molle from Portugal), and W. 248 (Kenya Ploughman from Kenya) were resistant to all the three rusts. It was significant to observe that the 12 varieties, which showed high resistance to the newly-isolated Race 122 of black rust, included E. 572, E. 581, E. 871, E. 1913 and E. 2025; almost all the other indigenous and foreign varieties in the collection, including several improved wheats, are susceptible to this new virulent race of black rust.

(ii) *Breeding for resistance to loose smut.*—Seeds from loose-smut inoculated ears of 84 varieties were grown this year for studying their reaction to the disease. A number of exotics, *e.g.*, E. 581, E. 952, E. 957, E. 2025, and several N.P. wheats, including N.P. 797, N.P. 798, N.P. 799 and N.P. 809, and a few hybrid derivatives in advanced generations were observed to be free from smut.

(iii) *Breeding for resistance to bunt disease.*—The work on hill bunt (*Tilletia* spp.) was in progress at the Simla Sub-station and on the Karnal bunt (*Neovosia indica*) at Karnal. A collection of 146 indigenous and exotic varieties was under study at Simla. Infection of hill bunt there was very heavy during the year and although a majority of the varieties tested showed high susceptibility, E. 201, E. 56, E. 740, and E. 2327 were found to possess a high degree of resistance and E. 187 and E. 872 were fairly resistant. Suitable crosses were attempted to incorporate this resistance into improved varieties.

At Karnal, incidence of *Neovosia* bunt was low, both under natural and artificial conditions of inoculation. This year's results have, therefore, not given any clear-cut indications regarding resistance to this bunt.

(iv) *Breeding wheats for growing under barani and other agronomic conditions.*—In order to select varieties suitable for different agronomic conditions, 40 varieties, which included a number of hybrid derivatives, were tested for performance under normal and late sowings, in unmanured and heavily manured plots and under irrigated and *barani* conditions. It was significant to observe from the results that three newly-evolved, rust resistant strains, *viz.*, H.D. (52)-46, HD(52)-66 and HD(52)-35, can be termed all-purpose wheats; they are suitable for early and late sowing, for irrigated and unirrigated land, and they have shown remarkable standing power and excellent response under low, as well as high, fertility conditions. HD(52)-46 appeared to be the best in all these respects. Besides, these strains possess good grain quality and resistance to smut also.

(v) *Breeding for resistance to drought and to lodging.*—One hundred and sixteen wheat varieties, covering a wide range of maturity, were tested for their performance in the field under *barani* conditions. Observations recorded periodically on soil-moisture revealed that a moisture stress had been created during crop growth

and development. The best performance, under these conditions, was given by the rust resistant strain, HD (52)-66, which was followed by HD (53)-87 and HD (52)-46.

A set of 100 varieties was studied for reaction to lodging. This was the second year of experiment. The lowest percentages of lodging were recorded in: E. 558 (Gabo), E. 559 (Kendee), HD (52)-62, N.P. 781, E. 821 (Insignia-49) and N.P. 771. For introducing lodging resistance into improved varieties, which are otherwise very desirable, crosses were made between N.P. 710 and other N.P. wheats, with the two Cambridge wheats, *viz.*, E. 2628, and E. 2629, which were last year observed to be highly resistant to lodging, and also with some other indigenous and exotic varieties.

(vi) *Genetics of rust resistance and other characters.*—The mode of inheritance of rust resistance, of resistance to lodging and of a number of ear and grain characters was worked out from detailed studies in several intervarietal, and in a few interspecific, hybrid combinations. In three crosses, the F_1 reaction indicated that susceptibility to black rust was dominant, the F_2 segregation being 13 susceptible : 3 resistant; in a fourth cross, however, the F_1 was resistant to black rust and the F_2 segregated for three complementary genes into 37 susceptible : 27 resistant. In respect of brown rust, the F_1 was resistant in two crosses and the F_2 segregated on a trigenic or digenic basis giving the ratios of 45 resistant : 19 susceptible and 9 resistant : 7 susceptible; in a third cross, the F_1 was susceptible and in the F_2 a ratio of 3 susceptible : 1 resistant was obtained. As regards yellow rust, F_1 showed resistance in four crosses; three of these gave a 3 resistant : 1 susceptible F_2 ratio, while the fourth segregated in the F_2 into 57 resistant : 7 susceptible indicating the operation of three gene loci. These studies were carried out in the field on plants inoculated with a mixture of races of each of the above-mentioned rusts at the adult plant stage.

The mode of inheritance of seedling-reaction to individual races of black rust was studied under controlled conditions in the glass house. For Race 15, the F_2 segregated into 15 resistant : 1 susceptible in two crosses and into 3 resistant : 1 susceptible in a third cross. For Race 42, a ratio of 13 resistant : 3 susceptible was observed in the F_2. The F_2 segregation in respect of Race 75 was observed to be 15 resistant : 1 susceptible in the three cross combinations studied.

With regard to lodging, the results confirmed last year's findings that resistance was governed monogenically, the F_2 ratio being 3 susceptible : 1 resistant.

(vii) *Evaluation of wheat varieties with regard to chapatee-making and baking qualities.*—Attention is also being devoted to the incorporation of desirable grain characters conducing to superior *chapatee*-making and baking qualities in the improved varieties. Techniques for evaluating *chapatee*-making and *maida* qualities were being standardised. Steps have been taken to establish in this Division a milling and baking laboratory on modern lines, with the co-operation of the T.C.M.

(viii) *World Catalogue of Genetic Stocks in wheat.*—This work is being done in co-operation with the F.A.O. During the year, descriptions of 38 indigenous wheat varieties were recorded and tabulated as per international specifications.

(ix) *Yield trials of promising varieties.*—With a view to testing the suitability of some of the newly-evolved N.P. wheat varieties to the different regions of the country, yield trials were conducted at 40 locations covering the important wheat-growing tracts. The varieties under test included those, like N.P. 792, N.P. 797, N.P. 798 and N.P. 799, which are highly resistant to black and brown rusts and to loose smut, and also those of proven merit, such as N.P. 710, N.P. 718, N.P. 758 and N.P. 761. In Bombay State, N.P. 797 did very well at Vijaypur, Dabhoi and Dohad, thus bringing out its suitability to that tract. In Saurashtra, N.P. 710 did best; N.P. 798 came out as the highest yielder at Sardargarh and Mahuva in that State. In Rajasthan, N.P. 718 was still the best; this variety is now becoming increasingly popular in the Delhi and Rajasthan area. In Orissa, N.P. 797 stood first at Cuttack and Mendhasal, while at Sambalpur N.P. 718 did the best; N.P. 761 also did equally well at Cuttack. Trials conducted in the Malwa tract of Madhya Bharat and Bundelkhand tract of U.P. brought out the superiority of N.P. 710, N.P. 729, N.P. 718 and N.P. 797 under *barani* and of N.P. 797 and N.P. 798 under irrigated conditions.

In the trials conducted in the hills of Punjab, U.P. and Himachal Pradesh, N.P. 770 and N.P. 809 again showed their superiority; N.P. 813 is another wheat which has given excellent performances. In the Nilgiris (South India), a selection from *T. dicoccum* ("Rishivalley") has given the highest yields and has shown resistance to brown and yellow rusts.

(x) *Seed production and supply.*—The demand for seed of improved N.P. varieties of wheat from all parts of the country totalled 7,675 mds; of this only 2,756 mds. could be supplied from the stocks of the Institute and its sub-stations to Community Project areas, state departments of agriculture and private indentors.

2. *Breeding rust and smut resistant barleys*

Breeding for rust resistance in this crop is also being done simultaneously with similar work on wheat: for barley is a collateral host of the black and the yellow rust of wheat.

The collection under study comprised 142 exotic and 64 Indian barley varieties. Tested under artificial conditions of inoculation, 28 exotic and 20 Indian types were free from black rust and several among them were free from yellow rust. Out of 28 indigenous and foreign varieties critically tested for resistance to loose smut, 3 exotic varieties, *viz.*, B. 47(Afghanistan-1), B. 237 (B. 114 Roseworthy Oregon) and B. 240 (Ko. Sr. 40/13 Svalof Yemer) showed freedom from the diseases. A suitable hybridisation programme is well under way for breeding superior disease resistant strains. With regard to lodging, C. 141, B. 137, B. 148 and B. 229 were found to show a considerable degree of resistance.

3. *Hybrid Maize*

This work, which is being done since 1946 under a scheme financed by the Indian Council of Agricultural Research, was expanded on a regionalised, all-India basis with financial assistance from the I.C.A.R. and with the co-operation of the Rockefeller Foundation of the U.S.A. This Division has been entrusted with the co-ordination of the work under the expanded scheme.

(i) *Collection, maintenance and testing of open-pollinated varieties.*—Two hundred and twenty-four indigenous and foreign varieties were under maintenance; these included 44 open-pollinated varieties received during the year from North and South America and 33 Indian open-pollinated varieties. Jelicose and Amarillo-de-Cuba, which have done very well at Delhi during the past few years, was increased for large scale trials, including some in cultivator's fields in Delhi villages. None of the other exotic varieties were found to be superior in yield to the indigenous, Kanpur T-41, and the U.S. Hybrid N.C. 27.

(ii) *Introduction, production, maintenance and evaluation of inbred lines.—Indian inbreds.*—A total of 787 flint inbreds, in various generations of inbreeding, were grown in the field. Of these, 146 were tested in top-crosses for general combining ability; 11 of them were finally selected as good combiners.

Exotic inbreds.—Forty-two exotic inbreds, constituting parental strains of the U.S. dent hybrids which have done very well in India—*viz.*, N.C. 27, Texas 26, U.S. 13, Dixie 11 and a few others, were maintained, multiplied and utilised for the production of double-cross seeds of these hybrids, on a small scale initially, in India.

Fifty-two flint and dent inbreds, received from South America with the co-operation of the Rockefeller Foundation, were grown for assessment. A majority of them proved rather late maturing as compared to Indian inbreds; a few among the former inbreds have been used for making single crosses with Indian inbreds.

(iii) *Testing of inbreds in top-crosses and single crosses for determining their combining ability.—Top crosses.*—Five trials were conducted with top crosses obtained from 146 inbreds evolved from Indian and foreign varieties. Ninety-seven of these top crosses significantly outyielded K. T. 41, the standard Indian variety used as the pollen parent. Considering the yield given by K.T.41 as 100·0, the yields of the top crosses ranged between 100·5 (for T.C. 481) to 184·0 (for T.C. 108F). Fifty three of these top crosses gave significantly larger yields than the top-performing U.S. hybrid, N.C. 27.

In top crosses, about 86 per cent of inbreds evolved from foreign varieties outyielded K.T. 41, whereas among the Indian inbreds, top crosses of only 50 per cent outyielded K.T. 41. This clearly indicates that genetic diversity is an important factor to reckon with in the production of high-yielding hybrids.

Single and double crosses.—Five trials were conducted with 90 single and 22 double crosses produced in this Division. Of these, 15 single crosses and 1 double cross significantly outyielded K.T. 41 by 0·59 (S.C. 90 1F) to 46·20 (S.C. 32 1F) per cent; the increased yields over N.C. 27 given by ten among these crosses were statistically significant.

(iv) *Trials with U.S. maize hybrids.*—Trials with 7 top-performing U.S. hybrids were conducted at 12 locations in different States of India. At Karimnagar (Hyderabad), Almora (U.P.), Muzaffarpur (Bihar), Udaipur (Rajasthan) and Srinagar (Kashmir), Dixie 18 gave about 48 per cent more yield than the best locals. Texas 26 gave about 45 per cent more yield than the best local at Udaipur and 104 per cent at Almora. At Arbhavi (Bombay), Katrain and Nagrota (Punjab), the local varieties outyielded the U.S. hybrids this year.

Sufficient seed has been produced at Delhi of the U.S. maize hybrids—N.C. 27, Texas 26 and U.S. 13, for conducting trials next year at about five locations.

4. *Jowar and Bajra*

The work on these crops is directed towards the production of improved varieties suitable for north India in general and Delhi region in particular. Studies were also in progress on the utilisation of hybrid vigour with a view to evolving high yielding hybrids.

Jowar.—About 200 indigenous and exotic strains were under study. Korgi, a strain introduced from East Africa, possessed the boldest seed in the collection, the 100-grain weight being 5·5 gms. as compared to the range of 1·0—4·1 gms. in the remaining types. The yield performance of Korgi was, however, rather poor. The stem borer, *Chilo zonellus*, caused severe damage to the crop ; in general, early varieties were severely infested with the borers, whereas the late ones remained quite free.

Bajra.—A collection, comprising about 100 varieties, was under study with regard to the range of yield-contributing and other important characters. Extensive selfing and sibbing was done for the purpose of selecting superior inbreds for utilisation in the hybrid *bajra* programme. Sixty inbred lines, in the S_1 generation, were top-crossed with T-55 for determining the general combining ability. Selfing in S_1 inbred progenies has yielded 179 inbred cultures for the S_2. In a varietal trial, I.C. 1476 (Delhi) gave yield statistically at par with T-55 from the Punjab. A mass pedigree selection programme was initiated in these two varieties. Two pistil-less variants, hitherto not reported in *bajra*, were recorded ; suitable crosses were made to study the mode of inheritance of the character.

5. *Breeding for wilt resistance and early-maturity in arhar (Cajanus cajan)*

Sixty-four early maturing, wilt resistant lines, derived from the crosses—N.P. 51×U.P. Type 132, Brazil×N.P. 41, N.P. 51×Jamaica 40-28B and N.P. (W.R.) 15×N.P. 51, were critically tested in a wilt-sick plot along with improved types from some States and the older N.P. (W.R.) types. N.P. (W.R.) denotes New Pusa Wilt Resistant. Wilt infection in the hybrid derivatives ranged from 0.0. to 10·2 per cent ; the provincial types showed the following incidence of wilt : Madhya Pradesh—E.B. 3 (84 per cent), E.B. 38 (81 per cent); Hyderabad—C. 11 (29 per cent), C. 36 (39 per cent) ; Bombay—F. 52 (26 per cent), F. 18 (40 per cent) ; Uttar Pradesh—T. 17 (16 per cent), T. 132 (14 per cent). N.P. (W.R.) 15, a high yielding strain, showed 0·0 per cent infection both in the wilt-sick plot as well as in the critical tests carried out by the Division of Mycology and Plant Pathology of this Institute.

The lines derived from the crosses, Brazil×N.P. 41 and N.P. 51×Jamaica 40—28B, were about as early maturing as E.B. 3 and E.B. 38 from Madhya Pradesh. The preliminary yield data recorded on the 64 lines under study showed that some of them gave 30 to 100 per cent more yield than the best control.

In a trial conducted at Behrampur (W. Bengal), the strains N.E. 40-6 and N.P. (W.R.) 15 stood first and second, giving a calculated yield of 10·4 mds and, 10·3 mds. per acre, respectively ; the control gave 8·2 mds. per acre.

6. *Breeding rust resistant and early-maturing strains of linseed*

A set of 183 promising rust resistant selections, derived from several hybrid progenies, was critically tested in the field for rust resistance under artificial inoculation, yield performance and other characters. Many of them were found to be early maturing, highly rust resistant and high yielding; the selections, such as S. 20, S. 4, S. 7, S. 63, S. 3, S. 2, S. 38 and S. 71 outyielded the best control by 20 to 50 per cent. The performance of these selections will be further tested.

Natural incidence of rust at Delhi was, this year, very mild. In a varietal trial, U. P. Type 477 stood first (1,494 lbs./acre) and it was followed by N.P. (R.R.) 9 (1,372 lb./acre) and others. The differences in yield were, however, not statistically significant.

In the yield trials conducted in the States, the following results were obtained. At Patna (Bihar) all the N.P. (R.R.) types outyielded the local—N.P. (R.R.) 5, 431 and 440 being the best yielders. At Cuttack (Orissa) and at Kanpur (U.P.), N.P. (R.R.) 440 stood first. At Gwalior (M.B.), U.P. Type 1 stood first, but its yields did not statistically differ from those given by N.P. (R.R.) 204 and 9. At Jullundur and Gurdaspur (Punjab) N.P. (R.R.) 45, 9 and 37 gave yields at par with the best local, K. 2. At Nagrota (Punjab hills) N.P. (R.R.) 38, and at Karnal (Punjab) N.P. (R.R.) 9 and 45, yielded at par with K. 2. At Nagpur (M.P.), the yield given by N.P. (R.R.) 204 was not statistically different from those of the locals—N. 3 and N. 55, but X4-29 yielded significantly more; the general yields in the trial at Nagpur were very low, ranging from about 20-80 lbs. per acre. At Jabalpur (M.P.), Bhubaneshwar (Orissa) and Bijapur (Bombay), the locals outyielded the N.P. (R.R.) types.

7. *Sesamum*

The collection comprising 30 N.P. types, 38 indigenous and 60 exotic collections, 4 species of *Sesamum*, and the related genus *Ceratotheca sesamoides*, was maintained. The crop was badly damaged by heavy rains during September and by wilt caused by *Macrophomina phaseoli*. It was remarkable to observe that N.P. 6, and a number of types extracted from the cross, *Sesamum orientale* × *S. prostratum*, withstood these adverse conditions, as compared to nearly all the exotic and indigenous types which suffered badly. The yield trial of the selections, extracted from the above-mentioned interspecific cross, was also vitiated to a great extent; however N.P. 6 and Selections: O, N, and S gave about 60 per cent more yield than the local control or the Punjab types included in the trial.

8. *Cotton*

Eighty eight indigenous and exotic types of *Gossypium hirsutum*, 33 types of *G. arboreum*, 17 types of *G. herbaceum*, *G. anomalum*, *G. thurberi* and *G. raimondii* were grown for maintenance and study. During the year under report, 54 foreign and indigenous types of *G. hirsutum* and 18 types of *G. barbadense* were added to the collection; these included a number of improved varieties of *G. hirsutum* and *G. barbadense* received from the U.S.S.R.

With a view to, mainly, improving the staple length and other fibre properties of the standard Punjab strains, 216F and 216F-14, which are suitable for the Delhi tract, a number of crosses were effected between these and some suitable indigenous and exotic *hirsutums*. The F_1 hybrid (216F×Co. 2) showed marked heterosis for the third year in succession ; it gave about 30 per cent more yield of seed cotton, as compared with the standard variety—216F, without deterioration in ginning out-turn and halo length.

9. *Spices and condiments*

(i) *Improvement of some essential-oil-bearing spice plants.*—This work, which was commenced during the year under report under an I.C.A.R. Scheme at four centres—*viz.*, Delhi, Aliabada (Saurashtra), Pusa (Bihar) and Katrain (Kulu Valley), covers the following five crops: *dhania* or coriander (*Coriandrum sativum*), *somf* or fennel (*Foeniculum vulgare*), *jeera* or cumin (*Cuminum cyminum*), *ajwain* (*Carum copticum*), and *sua* or dill (*Anethum graveolens*).

Indigenous and exotic collections, totalling 86 in *dhania*, 29 in *somf*, 26 in *jeera*, 28 in *ajwain*, and 18 in *sua*, were grown at the above centres. These cultures were grown in replicated row trials, where sufficient seed was available, and in observation rows. Detailed observations were recorded on a number of important agronomic characters in each of the crops with a view to preliminarily assessing the performance of the collections. Among the types which did well at one or more centres, the following may be mentioned: *dhania :* I.C. 3845, I.C. 951, I.C. 3833, I.C. 3477, I.C. 3634 ; *somf :* I.C. 3659 : *jeera :* I.C. 3811, I.C. 3723 : *ajwain :* I.C. 3641, I.C. 3692 and *sua :* I.C. 3677, I.C. 3818, I.C. 3815, I.C. 3700, I.C. 3724.

Manurial trials, using combinations of ammonium sulphate (0, 10 and 20 lb. N per acre) and superphosphate (0, 15 and 30 lb., P_2O_5 per acre) were conducted on local varieties at all the centres except Katrain. The general conclusion was that while the application of nitrogen alone was beneficial to the crops, phosphate alone tended to depress yield ; combinations of nitrogen and phosphate did not appear to be advantageous over nitrogen alone.

(ii) *Improvement of chilli* (*Capsicum annuum*).—Work on improvement of chilli in progress in this Division was augmented this year under an I.C.A.R. scheme with the object of laying emphasis on breeding for disease resistance. Fifty six new indigenous types, 53 exotic types and 19 different types of the following seven species of *Capsicum : C. annuum, C. fruitescens, C. pubescens, C. sinense, C. microcarpum, C. pendulum* and *C. chacoense*, received from the U.S.A., were added to the collection. Depending on the numbers of seeds and seedlings available, several of these collections were planted out in the field in replicates. Severe incidence of mosaic, leaf curl and other diseases was observed in almost all the cultures ; two cultures—"Puri Red" and "Puri Orange," were remarkably free from disease symptoms in the field. Seeds of these and many other types have been sent for testing to the Division of Mycology. During September, heavy rains water-logged the plot and caused very severe damage to the crop. Consequently, viable seed could not be collected from many cultures.

10. *Vegetables*

The work on vegetable breeding, being done in this Division during the past several years, now stands fully organised. A number of improved varieties of vegetables have reached a stage when they are in heavy demand from growers all over the country. The work is in progress both at Delhi and at the Central Vegetable Breeding Sub-station, Katrain (Kulu Valley); the latter is specially devoted to the breeding of European types of vegetables, such as winter cauliflower, cabbage, knol-khol, turnips, etc., and to the production of their seed. During the year under report, 5200 lbs. and 797 lbs. of vegetable seeds were produced at Delhi and Katrain, respectively, for large-scale distribution.

The results obtained from work done, during the year, on important vegetable crops are summarised below:

(i) *Tomato.*—Some of the lines derived from the crosses, Sioux × Improved Meeruti and Improved Meeruti × Red Cloud, gave very encouraging performances this year also. These crosses had been made with a view to combining the marked hardiness of Improved Meeruti with superior yield and fruit quality of the American varieties, Sioux and Red Cloud. Of these, Hybrid 10 was particularly remarkable as it gave high yields—both early yield and total yield. The autumn-winter crop suffered considerable damage due to water-logging caused by heavy rains during September and due to incidence of viruses. Yet, as will be seen from the table below, the performance of some of the strains was excellent.

Variety or Selection	Virus infection (per cent)	Damage due to water logging (per cent)	Yield in mds. per acre		
			Upto 18th Oct.	Upto 4th Nov.	Total Yield
Sioux	38·1	38·1	0·9	12·1	40·1
Improved Meeruti	8·3	9·1	7·5	62·9	124·1
Hybrid 10	14·5	8·7	19·6	71·9	122·1
Hybrid 11	13·2	14·4	14·0	07·3	102·5
Hybrid 14	18·9	26·3	18·7	62·8	84·1

Hybrid 10 was thus found to be as hardy as Improved Meeruti and more hardy than the others, especially Sioux. It produces high yields of attractive, good-quality fruits, suitable also for ketchup making. It is recommended both for autumn-winter and spring-summer crops. The fruits of Improved Meeruti are, comparatively, not so good in quality.

During the spring-summer crop also, these lines, especially Hybrid 10, gave a very good performance as will be seen from the table below :

Variety	Yield per acre (Mds.)
Sioux	206·6
Improved Meeruti	179·4
Hybrid 10	238·9
Hybrid 11	229·6
Hybrid 14	221·2

F_1 hybrids of Improved Meeruti × Sioux again exhibited marked hybrid vigour. The yield performances were as follows :—

Parent or Hybrid	Average yield per plant in ounces		
	Upto 30th Oct.	Upto 15th Nov.	Total Yield
Improved Meeruti	4·7	7·6	8·2
Sioux	7·1	9·5	10·4
F_1 (Improved Meeruti × Sioux)	12·1	15·0	15·4
F_1 (Sioux × Improved Meeruti)	10·8	13·5	13·7

As before, the cross (Improved Meeruti × Sioux) gave a better performance than the reciprocal. The male sterility character has been incorporated into these two varieties ; the combining ability of these new lines will be determined next year. This method is expected to make the commercial production of seed of hybrid tomato easier and cheaper.

(ii) *Bhindi* (Okra : *Abelmoschus esculentus*, syn. *Hibiscus esculentus*).—Further selections were made in the progenies of the 91 hybrid derivatives selected last year. Selections Nos. 66, 72, 81 and 91 were observed to be about 10 days earlier than the standard variety, Pusa Makhmali. Selections Nos. 39 and 40, though somewhat late, produced attractive dark green fruits. Further selections were made for five-edged, half-round or fully-round characters of the fruit in early, mid-season and late groups.

From crosses made between the 8-edge fruited, mosaic tolerant, late varieties with the early, 5-edge fruited Pusa Makhmali, a large number of selections were under study. About 50 of these selections, possessing 5-edged fruits of good quality, remained free from the yellow-vein mosaic disease till the end of the crop season. These selections will be further tested.

The seed of Pusa Makhmali was multiplied for distribution to growers.

(iii) *Brinjal* (*Solanum melongena*).—The indigenous variety—Wyanad Giant (I.C. 3517) was found to possess attractive, dark-purple, medium-sized, round fruits. It was crossed with Pusa Purple Round to further improve the fruit colour in the latter variety. Among the purple, long-fruited types, Pusa Purple Long, continued to be the best; its seeds were multiplied for distribution.

(iv) *Garden pea*.—Among the early types, Yates Early Crop—a variety from Australia, gave the highest calculated yield of about 164 mds. of green pods per acre; Early Badger stood second with 148 mds. Yates Early Crop bears attractive green pods having 6-7 peas of medium size. In the mid-season group of table peas, Bonneville again gave, in a yield trial, the highest yield of about 210 mds. of green pods per acre.

Among the grain-type peas, Hoshiarpuri—a green, round-seeded, mid-season variety gave the highest calculated acre-yield of about 40 mds. grain per acre.

(v) *Onion*.—Among the introduced varieties of yellow, or white—skinned onions, Early Grano, Byar Grano and H 4503-6 gave remarkably high yields of big-sized bulbs as compared to the control, Pusa Red.

Variety	Average (Calculated) yield per acre (mds.)	Average size of bulb (oz.)	Days from transplantation to maturity
Early Grano	843·3	5·1	142
Byar Grano	803·4	4·3	160
H. 4503-6	783·5	4·2	130
Texas Grano	634·8	4·3	142
White Grano	568·4	3·6	160
Pusa Red (control)	382·5	2·3	155

The above high yielding varieties, especially H. 4503-6, are very suitable for use as spring onion as their bulbs develop early.

(vi) *Sweet potato* (*Ipomoea batatas*).—A seedling selection from Norin, an introduced variety, did very well at Delhi as regards high total yield and yield of better-grade tubers. The selection produces attractive tubers and is likely to become popular in north India and elsewhere where red-skinned varieties are preferred.

Variety	Average yield of tubers per acre (in lbs.)			
	A grade	B grade	C grade	Total
Seedling selection from Norin	3859	1997	1451	7307
Norin (E.C. 4160)	3024	1975	2007	7006
Pusa Suffaid (control)	1543	1568	2770	5881

The trial will be repeated next year.

(vii) *Water-melon.*—Seeds of the varieties—Asahi Yamato and New Hampshire Midget, introduced from Japan and the U.S.A. respectively, were multiplied for distribution. Crosses were made between the indigenous variety, Farrukhabadi, which is high yielding but produces fruits of rather inferior quality, and Asahi Yamato whose fruits are of excellent quality.

(viii) *Central Vegetable Breeding Sub-station, Katrain (Kulu valley).*—The charge of this Sub-station, which was established in 1949 under the direct control of the Ministry of Food and Agriculture, was transferred to this Division in April, 1955. The main objectives of the Sub-station are: (*a*) to undertake systematic research for the breeding of superior varieties of vegetables—especially of the temperate ("European") types, such as cabbage, cauliflower, knol-khol, turnip, etc., and (*b*) the production of quality seed of the selected among these varieties on a commercial scale.

Winter vegetables.—These include European type vegetables, such as cabbage, winter cauliflower and others mentioned above, on the improvement of which little work has so far been done in India. Production of quality seed of these vegetables on a commercial scale has not yet been accomplished in this country; consequently, large quantities of these seeds have to be annually imported from abroad. It is, therefore, gratifying to record that, to start with, best quality seed of Snowball-16, a Dutch variety of winter cauliflower which has given excellent performances both in the hills and plains of India, has been produced under controlled conditions at this Sub-station for the first time in the country. Such work is being extended to other varieties of winter cauliflower and to other temperate vegetables, including cabbage, turnip and carrot. Improved methods of seed production are also being worked out in them with much success already, and a programme of planned hybridisation has been put under way. The latter includes hybridisation between genetically diverse groups such as the Asian and European types of vegetables like carrot, turnip and radish, inbreeding work for the ultimate production of superior hybrids and the evolution of intra-sterile and inter-fertile lines in the self-incompatible vegetable crops, such as cabbage, cauliflower, turnip, knol-khol and radish, for utilisation in the commercial production of hybrid seed in them.

Substantial additions have been made to the indigenous and exotic collections of varieties of these vegetables and they are being evaluated from the stand-point of either direct commercial exploitation or for use as breeding material. The following are the important varieties which have appeared very promising. *Carrot:* Coreless (E.C. 5840), and the Japanese strains of Nantes (E.C. 6027 and 6028). *Peas:* Early Badger among the early group, the *darantia kaip* varieties—Lincoln and Green Feast, and the smooth-seeded, Kanawari (Simla *matar*) among the mid-season group; N.P. 29, so popular in the plains, has given excellent yields of green pods as well as grain. *Leafy mustards:* The vigorous Japanese type (E.C. 6773) which gave excellent leaf yields both at Delhi and Katrain, and another Japanese type, Komatsuma (E.C. 6775), which might be found useful in preference to the common *sarson saag.* *Turnip:* Japanese White (E.C. 6762), which is the earliest to form "bulbs"—in 30 days, as compared to 45-65 days taken normally in turnip. Other excellent varieties are Snow Ball and Golden Ball. *Cabbage:* Golden Acre, and Surehead. *Cauliflower:* Snow Ball.

Summer vegetables.—Extensive collections of exotic and indigenous varieties of vegetables, both from the hills and plains of India, were under study. Those worthy of special mention include the following: *Tomato:* Sioux, the earliest-fruiting, large fruited American variety, has given excellent performances at Katrain as well as at several centres in India and it is becoming very popular. *Brinjal:* Pusa Purple Long, Pusa Purple Round and Pusa Clustered; the last-named variety has done well especially in the hills. *Spring radish:* A medium-early, scarlet-skinned Danish variety (E.C. 8783) and two dark-skinned Swiss varieties (E.C. 8748 and E.C. 8749) which form roots early and are notably slow-bolting. *French bean:* A yellow-podded variety, Cherokee, received from the Asgrow Seed Company. *Cucumber:* The Japanese variety, Kaga Aomoga Fushinavi (E.C. 5082) and an early pickling type from Denmark (E.C. 8834) which produces marketable fruits in 50 days. *Vegetable marrow:* Long Bush Green (E.C. 8062) from Australia. *Watermelon:* Canada Early (E.C. 4677) which at Katrain proved to be earlier than the Japanese variety, Asahi Yamato, and the American, New Hampshire Midget.

11. *The Central Seed Testing Station*

This came into operation in this Division, in October 1955, under the Second Five Year Plan as a first step towards a nation-wide organisation which will be devoted to work on seed certification in general and vegetable seed certification in particular. At present, commercial supplies of reliable, good quality vegetable seeds are not easily obtained in the country.

The task of establishing a properly-equipped seed testing laboratory was first undertaken. Several samples of vegetable seeds were obtained from a number of markets. Utilising the information obtained from their analysis, steps have been taken to evolve standards and schedules, which may be applicable to this country, in respect of important seed characters, such as germination capacity, purity, true-to-type performance, presence of inert and foreign matter including seeds of weeds and other plants. To this end, a museum of weed seeds, which may be met with in commercial seed stocks of farm and vegetable crops, is being organised.

12. *Improvement of pasture grasses and legumes*

This work is being done under a scheme financed by the I.C.A.R. During the year, the Agrostology Section, which was functioning in the Division of Agronomy for the past nine years, was transferred to this Division.

About 180 items of grasses and legumes were added to the collection which now totals about 508 items. Selection work was continued in the grasses—*Cenchrus, Pennisetum, Dichanthium, Heteropogon* and *Chrysopogon*. A strain of *Heteropogon contortus* (I.W. 935) showed excellent growth under rainfed conditions; its spear, unlike in other strains, is rather weak and non-penetrating. *Dichanthium caricosum* (I.W. 955) from South India was very leafy and remained green even during January. In *Cenchrus*, drought resistant selections (I.C. 2136, I.C. 2137, and E.C. 5603), and some superior grazing types (from Delhi, Hissar and Ajmer) and cutting types (E.C. 5598, Australia-49, Delhi-67) have been selected. Under conditions of

lfing, seed set could not be obtained from *Chrysopogon montanus*, while *Dichan-um annulatum* and species of *Cenchrus* and *Pennisetum* gave good seed setting. study of selfed generations (S_1 and S_2) in these grasses did not reveal any loss of ant vigour through inbreeding.

Cytology and Cytogenetics

13. *Crop improvement through colchicine-induced autopolyploidy*

(i) *Brassica and Linseed.*—In autotetraploid *toria* (*Brassica campestris* var. *ria*) further mass pedigree selection has resulted in the building up of elite populations with greater frequencies of highly seed-fertile plants. Selection is also eing exercised for greater number of secondary and tertiary branches per plant ith a view to further raising plant yield in the autotetraploids. The yield trial nder way at Delhi was, unfortunately, vitiated owing to severe aphid attack.

In autotetraploid linseed, selection for increased fertility was continued; out f autopolyploid lines obtained from 14 different diploid strains, marked increases in ed fertility were observable only in the case of autotetraploids of N.P. (R.R.)63. he seed fertility of all these autotetraploids is yet significantly lower than that in ie diploid.

(ii) *Fodder crops.*—The progenies of the tetraploid berseem (*Trifolium alexan-rinum*) and *Senji* (*Melilotus indica*) plants produced during 1954-55 were grown in oth pots and in the field. The chromosome numbers of 421 C_1 plants were deter-nined in root tip squashes. The numbers showed that (*a*) several C° plants should ave been sectorial or periclinal chimaeras and (*b*) levels of ploidy higher than etraploidy did not occur. Cytological studies among C_1 plants showed an average uadrivalent frequency of 2·3 to 2·8 per cell in berseem and 3·0 in *senji*. The uadrivalents were mostly either rings or simple chains. Seed setting was much ower in tetraploids but it appeared that the increased inflorescence number in erseem tetraploid plants would to a greater extent off-set the disadvantage arising rom a lowered seed-setting per inflorescence.

Berseem tetraploids showed better growth and gigas characters, both in pots nd in the field, while tetraploids of *senji* were poor in growth and much less vigorous han the corresponding diploids. Tetraploid berseem had a CaO content of 3·51 er cent while the diploid had only 1·54 per cent. There were no appreciable differences n nitrogen and P_2O_5 contents. The results so far obtained give hope that etraploid berseem may be economically an improvement over the diploid.

14. Monosome genetics (*Triticum aestivum*)

F_1 plants from the crosses between Chinese Spring monosomes and the variety Co-neta Klein (E. 671) were studied. The variety Cometa Klein had originally been ob-ained from Argentina and is resistant to the Indian races of yellow rust: 13,19,31, A,), E, F, G and M. There were both 41 and 42 chromosome plants in all the 21 F_1 lines nd these were isolated by determining the chromosome numbers during meiosis in nicrosporocytes. From a study of the characters in which the F_1 monosomes and disomes differed from each other, it is inferred that Cometa Klein carries the following factors in the chromosomes mentioned: (*a*) a recessive gene 'a' for awn develop-ment and possibly some factors for chromosome synapsis in chromosome III; (*b*) the recessive alleles of the awn suppressor genes Hd and B_2 in chromosomes VIII and X respectively; and (*c*) factors for ear shape in chromosome IX.

The cycle of crosses between Chinese Spring monosomes and Kenya C. 10854 (E. 220) and Rio Negro (E. 952) was completed, the object being to locate the chromosomes on which genes conferring resistance to black and brown rusts respectively are located.

15. *Cytology of species and species hybrids in Abelmoschus*

The chromosome numbers in both *A. manihot* var. *tetraphyllus* (syn. *Hibuscus tetraphyllus*) and *A. manihot* var. *pungens* (syn. *H. pungens*) were for the first time found to be $2n=138$. In view of an earlier report from this Division that the F_1 hybrid (*A. manihot* var. *tetraphyllus* $\times$ *A. manihot* var. *pungens*) is sterile and also that the chromosome number of *A. manihot* (syn. *H. manihot*) has been reported by Japanese workers as being $2n=60$-68, a cytotaxonomic revision of this material appears necessary. Further studies are in progress to examine whether *A. manihot* var. *tetraphyllus* and *A. manihot* var. *pungens* could be given specific ranks—*A. tetraphyllus* and *A. pungens*, respectively, the Japanese species being *A. manihot*.

The F_1 hybrid, $2n=65$, (*A. tuberculatus*, $n=29\times$ *A. ficulneus*, $n=36$), was totally sterile and formed an average of 1·6 chromosome pairs per cell, the range of pairs per cell being 0-7. The F_1 hybrid($2n=134$), (*A. manihot* var. *tetraphyllus*, $n=69\times$ *A. esculentus*—cultivated *bhindi*, $n=65$), was also sterile and showed 30-42 chromosome pairs per P. M. C. Meiosis was also studied in pollen mother cells of the backcross of amphiploid (*A. esculentus*, $n=65\times$ *A. tuberculatus*, $n=29$) with cultivated *bhindi* (*A. esculentus*); trivalents, bivalents and univalents were met with. The range of trivalents and bivalents per cell was 3-11 and 54-65, respectively. The backcross hybrid was partially seed fertile.

16. *Linum*

L. mysorense was found to possess $2n=60$ chromosomes, a number not so far reported in a naturally-occurring species of *Linum*.

17. *Cytology of intraspecific hybrids in Brassia campestris* ($n=10$)

In order to understand the relationship between *toria* (*B. campestris* var. *toria*), yellow *sarson* (*B. campestris* var. *sarson*), brown *sarson* (*B. campestris* var. *dichotoma*) and Burma *sarson* (*B. campestris* var. *chinensis*), all belonging to the *campestris* group of *Brassica*, the F_1 hybrids and F_2 populations of the crosses of *toria* with the other three varieties were studied cytologically. An estimate of the relationship was obtained by calculating the hybridity coefficient from inversion data. The values for the different F_2 hybrids were: 0·033 for yellow *sarson*$\times$*toria*, 0·037 for Burma *sarson*$\times$*toria*, and 0·018 for brown *sarson*$\times$*toria*. This suggests that of the three *sarsons*, brown *sarson* is the most closely related with *toria*. That, apart from the inversions observed, the differences between *toria* and the three *sarsons* are largely of the cryptic structural type, is suggested by the varying degree of fertility observed in F_2 populations of these hybrids.

18. *Cytotaxonomical studies in Indian grasses:*

Cytological studies were carried out in 27 species belonging to 15 genera of the Tribe Andropogoneae and 21 species belonging to 8 genera of the Tribe Paniceae. Intra-specific polyploidy was observed in *Sehima nervosum*, *Bothriochloa ischaemum*

Bothriochloa intermedia, Dichanthium annulatum and *Themeda anathera.* Accessory or 'B' chromosomes were observed in *Panicum coloratum* and *Chrysopogon gryllus.* The presence of 'B'-chromosomes had no visible morphological effects but an accumulation of 3 or more of them led to disturbed anaphases and some degree of pollen abortion.

Studies in the genus, *Brachiaria,* showed that *B. brizantha,* which is a very promising fodder grass under Delhi conditions, is triploid and is consequently sterile. In the genus, *Pennisetum,* the chromosome numbers $2n=10$ and 32 were recorded in *P. ramosum* and *P. massaicum* respectively. These numbers suggest two additional basic chromosome numbers, X=5 and 8, for this genus. The existence of a *Pennisetum* species with $2n=10$ supports the view held by Avdulov that the original basic numbers of all Gramineae is probably 5.

19. *Embryological studies in oilseed plants*

A detailed study of the embryology of *Brassica juncea* was carried out. Development of the embryo sac was found to be of the normal Polygonum type. Occasionally twin embryo sacs were found. Endosperm was nuclear to begin with but later became cellular and most of it was consumed during the maturation of the seed.

20. *Cytological techniques*

Excellent spread of chromosomes was obtained when root tips of different plant material, such as wheat, paddy, *Vicia* and tobacco, were gathered from seeds soaked in castor oil for two hours prior to sowing. Seeds are presoaked in castor oil (*Ricinus communis*) for 2 hours, and germinated in Petri dishes on moist filter papers. The root tips are fixed in acetic alcohol (1 : 3) at 10 to 14°C for 24 hours, washed successively with 70 per cent alcohol (15 minutes) and water (10 minutes), hydrolysed in 1 HCl at 60° C for 15 minutes and stained in leucobasic fuchsin for 30 minutes. The stained tip is squashed under a cover glass in a mixture of acetic acid and N-butyl alcohol (1 : 1), passing through two changes of N-butyl alcohol and mounting in balsam.

21. *Effects of chemical mutagens on plant chromosomes*

During a study of the effects of vegetable oils on plant chromosomes, it was found that the fatty oils extracted from *toria* (*Brassica campestris* var. *toria*) and castor (*Ricinus communis*) are capable of inducing chromosome fragmentation. Soaking the seeds for more than two hours in these two oils led to fairly extensive chromosome breakage in *Triticum monococcum, T. dicoccum, T. aestivum, Oryza sativa* and *Vicia faba.* Coconut oil from *Cocos nucifera*, gingelly oil from *Sesamum orientale,* groundnut oil from *Arachis hypogea,* linseed oil from *Linum usitatissimum* and pure ghee were also used in the study. Soaking in linseed oil for 2 hours inhibits germination completely. Ghee has no effects on the somatic chromosomes. Gingelly oil has also practically no adverse effects. The other oils cause varying degrees of aberrations. The cytological effects of the fractionated components of the different oils are under study.

22. *Induction of mutations through the use of radiations*

Work was started in October, 1955, on the induction of mutations through the use of radioactive isotopes, like 32_p and 35*s* and of X-rays, ultra-violet rays and fast neutrons. The phenotypic and cytological effects of these treatments were recorded. It was observed that 32_p treatment induced early flowering in both wheat and cotton

From the data recorded, the following general conclusions can be drawn : (1) The cytological effects of a given dose of beta or neutron or X-ray radiation vary from crop to crop. While some crops like wheat are easily affected. crops like paddy are less sensitive to radiation damage. In general, it appears that plants with large chromosomes are more radio-sensitive than plants with small chromosomes. Some plants like linseed appear to be extremely insensitive. Possibly, the presence of high oil percentage in these seeds has a buffering effect. (2) Polyploid species within a genus tend to be less sensitive than diploid species. This is because a change in one locus or chromosome is effectively suppressed or buffered by the chromosomes in the other genomes of a polyploid. It was also observed that the cytological effects of a given dose of beta radiation decrease from the diploid to the hexaploid wheats In the case of neutron treated material, however, the results are reversed. Nearly all the 42 chromosomes in bread wheat are affected in a high proportion of cells ; the treatment does not produce any adverse effects on cell metabolism or cell division, with the result that the cells continue to grow and differentiate normally, although the chromosomes have been drastically affected. Neutron radiation may hence be a potent tool for inducing mutations in polyploid plants.

23. *Use of Embryo Culture Technique*

A Unit for Embryo Culture was set up in October, 1955, for the purpose of using this technique to overcome cross-incompatibility problems in inter-generic and inter-specific hybridisation. As a first step in such work, suitable media for the culture of young embroys of some of the important crop plants were standardised. Embryos of wheat, maize and tomato could be successfully cultured in White's and Tukey's media. A medium comprising inorganic salts, 4 per cent sucrose and 10 per cent malt extract (pH, 6·5) was found to be very suitable for the culture of young embryos of *Brassica campestris* var. *toria*. Embryos of jute (*Corchorus olitorius*) showed maximum growth in White's medium containing 0·1 per cent of yeast extract with the addition of trace elements.

Crop Physiology

24. *Study of Drought Resistance in Wheat*

A replicated field trial was laid out, with and without irrigation, with four wheats, namely, N.P. 710, N.P. 718, Pb. C. 228 and Ridley. A similar trial was laid out under ' barani ' cultivation. There prevailed an appreciable soil-moisture stress, particularly in the first foot, from February onwards, in the unirrigated and ' barani ' plots. The grain yields of the four varieties did not differ significantly and the mean yields from the unirrigated and 'barani ' plots were 4/5 and ½, respectively, of that of the irrigated plot. Periodic determinations, after anthesis, of green leaf area, green stem length and of ear-greenness indicated that Pb. C. 228 and Ridley had a relatively less total green surface than the other two varieties. Since the yields of the four varieties did not differ, it followed that the extent of green photosynthetic surface did not completely determine the yield (on a reasonable assumption that the photosynthetic rate did not differ among the varieties). It would appear that the amount of photosynthate produced by the smaller green surface is adequate and that yield is primarily dependent upon the rate of growth

of the grains (fruits). Such a surmise, that factors like number and size (growth capacity) of grains determine yield, was further substantiated by the following observations. Periodic determinations of increase in grain weight per ear indicated significant varietal differences which were not correlated with corresponding differences in green surface. The rate of increase in grain weight did not materially differ under adequate soil moisture and drought for the first three weeks or so, in spite of a reduced leaf area under the latter and only subsequently was the grain weight under drought outstripped, due probably to a quicker yellowing of the ear. Identical results were obtained from similar observations on N.P. 792,797,798,799, 718, 720 and Pb. C. 281 grown in another 'barani' plot and on N.P. 710 and 718 raised under pot-culture.

25. *Plant Hormones*

In a pot-culture with wheats, N.P. 710 and Pb. C. 228, and two levels of nitrogen, sufficient and deficient, foliage spray of 75 p.p.m. alpha naphthalene acetic acid (NAA), at commencement of tillering, did not increase the grain yield. A similar result was obtained under field conditions. When NAA was sprayed with a wetting agent, or applied in lanolin paste, the grain yield of both the varieties was increased.

In a pot experiment with wheats, N.P. 710 and Pb. C. 228, soaking of seeds in 0, 0·1 and 1·0 p.p.m. solution of N.A.A. for 24 hours, followed by two temperature treatments, namely, 5°C for 2 weeks and room temperature for 2 days, it was found that none of the treatments increased the grain yield.

In another pot experiment involving wheats, N.P. 710 and 718, and spraying with 7 different hormones, namely, alpha naphthalene acetic acid, beta indolyl acetic acid, beta naphthoxyacetic acid, naphthalene acetamide, beta indolyl butyric acid, para chlorophenoxy acetic acid and maleic hydrazide at 75 p. p. m., none of the treatments was found to increase the yield.

In a field experiment with cotton, 216F, involving 3 auxins, namely, alpha naphthalene acetic acid, beta idolylbutyric acid and alpha indolyl acetic acid, 3 concentrations, namely, 20,40 and 80 p.p.m., and three times of spraying, namely, once, twice and four times, it was observed that IAA and IBA increased boll number and weight of seed cotton by 20 per cent, that 40 p.p.m. was the optimal concentration, and that more than one spray had an inhibiting effect.

Weed Control.—In a trial with pre-emergence application of weedicides, Dicotox (ethyl ester of 2,4-D), Fernoxone (sodium salt of 2,4-D) and Craig Herbicide (sodium 2, 4-D ethyl sulphate), to maize, significant increases in yield were obtained under the first two (50 per cent). Hand weeding was not effective because it could not be carried out at the proper time due to incessant rain.

Control of Kans (*Saccharum spontaneum*).—CMU was applied at the rate of 20, 40, 60 and 80 lbs. acre, respectively, in the end of September, 1955; in June, 1956, there was profuse growth in the control beds, whereas the treated beds showed increasing sparseness with increasing doses, the area covered being barely 20 per cent under 60 and 80 lbs. doses.

26. *Plant Nutrition*

In a field experiment, involving 3 wheats, N.P. 710, 718 and 797, and application of manganese, zinc, boron, copper and molybdenum to soil and as spray, only boron applied to soil, at the rate of 2·3 lb./acre, increased the yield over the NPK control by 4·2 mds./acre.

In two separate experiments, with paddy and wheat respectively, the residual effects of 'fritted trace elements' and of manganese, zinc, boron, copper and molybdenum, applied individually, in the previous season, were found to be negligible.

27. *Physiological investigations on autotetraploids of some oilseed crops (ICOC Scheme)*

In a comparative study of the growth of *toria*, diploid T 22 and a tetraploid elite A (*Brassica campestris* var. *toria*) under two spacings, 3′×2′ and 2′×2′, and two levels of nitrogen, 0 and 20 lb. per acre, it was found that, on the whole, the diploid responded better to wide spacing and nitrogen supply as indicated by increase in the number of tertiary branches under wide spacing and under 20 lb. nitrogen with close spacing. The fruit number was similarly increased. The yield per unit area was, however, reduced under wide spacing because of fewer number of plants. The effect of nitrogen on final yield was also not significant. The diploid yielded significantly more than the tetraploid.

In another field experiment involving spraying of one-month old plants with maleic hydrazide (500 and 1000 p.p.m.), naphthalene acetamide (100 p.p.m.), triiodobenzoic acid (500 p.p.m.), indolyl acetic acid (20 p.p.m.), naphthalene acetic acid (20 p.p.m.) and para chlorophenoxy acetic acid (20 p.p.m.), it was found that the first (500 p.p.m.), second and the last compound on the list increased the grain yield by 20 per cent by increasing the fruit number. The fruit number was also increased under 1000 p.p.m. maleic hydrazide, but as seed setting was adversely affected the final yield was reduced. The response of both diploid and tetraploid was similar and their grain yields did not differ.

In another field experiment under 'barani' cultivation, both the diploid and the tetraploid yielded equally well.

It was found, in conformity with observations reported last year, that the tetraploid was superior to the diploid in respect of size of seed and other organs but it did not outyield the diploid because of its inferiority in the number of secondary and tertiary branches and seed number per siliqua.

28. *Co-ordinated Scheme for investigation on micronutrients (I.C.A.R.)*

Symptoms due to deficiency of some micronutrients were studied in maize, tomato and mandarin grown in water culture. In maize, white stripes on the leaves and suppression of the growing point were characteristic of boron deficiency. Though growth was stunted under manganese, copper and zinc deficiencies, no other symptoms appeared. In tomato, interveinal chlorosis, brownish dots on the lamina and shedding of flower buds were characteristic of manganese deficiency and shedding of leaves and breaking off of the growing point, of boron deficiency. Under copper and zinc deficiency, growth was stunted and the leaf margins folded inward, particularly under the latter. The symptoms disappeared and normal growth was resumed after adding the deficient elements.

In mandarin, 'dieback' of the main shoot appeared, both under manganese and boron deficiency, when the seedlings were about 8 months old. Under boron deficiency, the upper leaves were very pale and leaf size was reduced while under manganese deficiency the upper leaves were chlorotic and some of the older leaves markedly mottled. Under zinc and copper deficiencies, growth was slightly stunted and leaf size was also reduced but no other symptoms had appeared so far.

In *mosambi* (on *Jambiri* stock) grown in river sand, scorching of lamina, starting from tip or margins, and crinkling were characteristic of potassium deficiency. Under nitrogen deficiency, the leaves were pale green, while under both these deficiencies, premature shedding of leaves occurred. The growth was stunted under N, P and K deficiencies, it being most marked under nitrogen deficiency, followed by potassium deficiency. No other symptoms of phosphorous deficiency had appeared so far.

Chemical analysis of leaf samples collected from healthy and affected trees (chlorosis and mottling) in the Institute orchard, revealed a consistently lower calcium content in the mottled leaves. Similar samples collected at the citrus orchard, Durgapur Farm, Jaipur, indicated a lower content of potassium, calcium and magnesium in the mottled leaves. Some of these trees were sprayed with magnesium and other micronutrients in the month of May, 1956.

Plant Introduction

The nucleus organisation, under which this work was being done since 1946 with financial assistance from the I.C.A.R., was expanded into a full-fledged, all-India Plant Introduction and Exploration Organisation.

During the year under report, 1861 seed samples and other planting material were introduced from abroad and 859 samples were collected from within the country; the entire collection now totals over 14,000 items. Particular attention was given to the introduction of foreign varieties of vegetables, such as cabbage, cauliflower, turnip, kohl rabi, carrot, radish, beet, lettuce, tomato and several varieties of garden flowers from Europe, America and Japan.

Among the older varieties introduced into India by this Division, mention may be made of Pusa Suffaid (*ex* China) sweet potato, several requests for the planting material of which were received from the Community Projects areas and from several farmers. About 54 mds. of vine-cuttings and 16 mds. of tubers of this variety were supplied for planting to these growers. The tomato variety, Sioux, has done very well in Orissa, besides its excellent performances reported from the States of Madhya Pradesh and Hyderabad; the variety is fast becoming popular. The Uttar Pradesh Department of Agriculture multiplied seeds of the garden pea variety, Early Badger, for conducting large-scale trials and of Bonneville and Delwiche Commando for supplying to the Government of Madhya Bharat; Delwiche Commando gave a good performance at Krishnagar (W. Bengal) also. White Algerian and Boris Opus, two introduced oat varieties, gave respectively, 30 and 50 per cent more yield of green fodder at the Cattle Breeding-*cum*-Dairy Farm, Kalso, Dehra Dun.

The important among the items introduced this year included the following: *Tomato*: Wiltmaster and Bison from the U.S.A., a "multiple" disease resistant variety—Menalucie, also from the U.S.A., and two wilt and nematode-resistant

varieties, Manzana and Res de Tempranos from Australia. *Cauliflower*: Snow Ball No. 16, an excellent performing late variety from Holland. *Papaya*: A hermaprodite variety from Australia. *Watermelon*: A very sweet, cream-fleshed variety-Shin Yamato, from Japan. *Muskmelon*: Delicious 51, Pennsweet and Minnesota Honey from the U.SA.; Delicious 51 is reported to be resistant to *Fusarium* wilt. *Strawberry*: Florida 90 and Dresden from the U.S.A. and a perennial variety from England. *Lucerne*: The drought resistant variety, "Uruguaya Clone 10", from the U.S.A. *Cotton*: Varieties of *Gossypium hirsutum* and *G. barbadense* from the U.S.S.R., U.S.A. and Africa. *Grasses*: Cold and drought-resistant strains of *Setaria sphacelata* and *Chloris gayana*.

Horticulture

Under the Second Five Year Plan, the Horticulture Section started in this Division is being separated out into the Division of Horticulture under the Institute which will cater to researches aimed at the improvement of fruits and fruit products. Of the 30-acre garden area, about 17½ acres have so far been planted to several varieties of various kinds of fruits, such as, mango, loquat, lime, orange and other citruses, grapes, guava, etc. The fruit nursery, comprising over 14,000 saplings, now covers about 2½ acres. During the year, about 20 acres of the garden land was inter-cropped with various vegetables. About 1,300 plants of different varieties were sold to indentors.

Botanical Sub-station, Pusa

The Botanical Substation, Pusa (Bihar) is a permanent sub-station under this Division. The main functions of the Sub-station include: (i) maintenance of crop collections, both indigenous and exotic, and testing their performance under north Bihar conditions, (ii) breeding and selection work in crops, like wheat, linseed, pigeon pea, maize, tomato, etc., with a view to evolving varieties suitable to the tract in which it is located, and (iii) multiplication of foundation seed stocks of N.P. varieties of crop plants for distribution to growers in that region. The sub-station also constitutes an important centre under the Co-ordinated Wheat Rust Control Scheme for the breeding of rust resistant wheats. The other Divisions of the Institute also conduct some of their experiments at this Sub-station.

The crop season during the year was favourable to crops, especially the *rabi* crops; some *kharif* crops, like *arhar* and *til*, were, however, damaged owing to floods caused by excessive monsoon rains.

In wheat, the incidence of yellow rust was rather mild, but that of black rust and brown rust was severe. N.P. 761 was again the best performing wheat variety; although the exotic variety, E. 871 (Frontiera), gave even better yield, its grain quality was poor. In a small scale trial, six exotic oat varieties gave 20 per cent or more yield of fodder than the control, N.P. 1; their calculated acre yields ranged from 14,000 to 19,500 lbs. as against 12,000 lbs. given by N.P.1. The *mung* variety, China No. 781, obtained through the Bombay Department of Agriculture, proved late and low-yielding at Pusa. In *urid*, sown in *kharif*, N. P. 4, 6 and 14 gave from about 58 to 110 per cent more yields than the local; the performance of Kandahar Mash was rather poor. The exotic type, Nebraska 852, of safflower (*Carthamus*

tinctorius) gave, in a yield trial, about 48 per cent more yield than the control, N.P. 30; this exotic type also possesses the highest oil content. An *elite* strain of autotetraploid *toria* gave, in a yield test, calculated acre yield of 5·1 mds. as against 2·9 mds. given by diploid *sarson*, commonly grown in the tract. Remarkable fibre yields have been obtained during the past few years from the exotic jute (*Corchorus capsularis*) type, E.C. 4142; this year the type gave, in a yield test, an average yield of 14·7 mds. of fibre per acre as against 11·2, 8·9 and 7·8 mds. given respectively by J.R.C. 212, J.R.C. 321 and D/154. In *C. olitorius*, J.R.O. 632 gave 13·0 mds. of fibre per acre as against 4·3 mds. given by Chinsurah Green. In tomato, Hybrid 10 and Hybrid 14, bred at Delhi, gave calculated acre yields of 333·6 and 304·1 mds., respectively, as compared to Sioux, which gave 167·7 mds. Besides these, a number of high yielding lines have been selected and fixed at Pusa from the cross, Sioux × Improved Meeruti; these will be further tested for yield.

Maintenance of indigenous and exotic collections and of nucleus seed of improved varieties in a number of crops was done. Over 400 mds. of pedigree seed of different improved N.P. types of crop plants were distributed to growers.

Experiments conducted for the other Divisions of the Institute included: the use of dicalcium phosphate and Kotka phosphate on wheat, the permanent and the New Manurial-*cum*-Rotational Experiments, and work relating to survey of incidence of pests and their control.

PROGRAMME OF WORK FOR 1956-57

1. Improvement of Indian wheat with special reference to evolving varieties resistant to rusts, smuts and bunt diseases, and to drought and lodging.

2. Study of the suitability of N.P. wheats and other breeding material to irrigated and *barani* conditions, and to special conditions—such as rich soils, late sowings, etc.

3. Study of the milling and baking and *chapatee*-making quality in wheat varieties.

4. Breeding for rust and smut resistance in barley.

5. Genetics of rust resistance and other characters in wheat.

6. Breeding for rust resistance and earliness in linseed and wilt resistance and earliness in pigeon pea (*arhar*).

7. Breeding for extra-long staple in cotton.

8. Trials of the recently evolved N.P. strains of crop plants, such as wheat, linseed, pigeon pea, tomato, etc., in the different States of India.

9. Investigations on the utilisation of hybrid vigour in maize, tomato, onion, *bhindi*, *jowar*, *bajra* and cotton. Trials of foreign inbreds and hybrids of maize on a regional basis in India.

10. Breeding of early ripening and high yielding varieties of *bajra* and fodder and grain varieties of *jowar*.

11. Breeding of some pasture grasses and legumes for northern India.

12. Study of wild relatives of crop plants, and their utilisation in plant breeding, in wheat, *bhindi*, etc.

13. Improvement of chilli through the breeding of disease resistant varieties.

14. Improvement of some essential oil-bearing spice plants, like coriander, fennel, etc.

15. Breeding superior varieties of water-melon and musk-melon.

16. Breeding of vegetables, including the European type vegetables, such as cabbage, winter cauliflower, turnip, etc. ; development of improved methods for the commercial production of quality seed in them.

17. Testing and certification of seeds of vegetable crops.

18. Induction and study of polyploidy as a method of crop improvement in oleiferous *Brassicae*, linseed, berseem, etc. ; yield trials of some promising lines of tetraploid *toria*.

19. Cytogenetical studies in some oleiferous *Brassicae*, linseed and *sesamum*.

20. Cytogenetical studies in species of *Triticum* and of interspecific and intergeneric hybrids involving *Triticum*. Monosome analysis for location of genes on chromosomes in *Triticum*.

21. Cyto-taxonomical and cyto-ecological studies in some Indian fodder grasses.

22. Induction of mutations in crop plants through the use of chemicals and radiations from radio-active isotopes, neutrons, X-ray and ultra-violet rays.

23. Studies on the incidence and induction of pollen sterility in crop plants.

24. Application of embryo culture technique to overcome embryo leathality in distant crosses.

25. Improvement of cytological technique.

26. Physiological studies on resistance to drought and lodging in wheat.

27. Physiological analysis of factors concerned with yield in wheat.

28. Influence of light and temperature on growth and development in wheat.

29. Physiological aspects of plant nutrition in wheat—studies on the relation between varietal differences in the uptake of nutrients.

30. Plant hormones—investigations on their role in growth and development in wheat and cotton, and on their use as weedicides.

31. Plant physiological studies in relation to the dieback disease of citrus.

32. Plant physiological studies on colchicine-induced auto-polyploids of oil-yielding plants, such as *toria*, linseed, etc.

33. Plant introduction and collection of indigenous plants of economic value ; their maintenance, evaluation and trials in Delhi and other States.

34. Horticulture—extension of the garden area for purposes of work on the improvement of fruits and fruit products.

35. Intensification of the programme for the multiplication and distribution of seeds of improved N.P. varieties of field and vegetable crops.

REPORT OF THE DIVISION OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

(S. P. RAYCHAUDHURI)

A. AGRICULTURAL CHEMISTRY

(a) SOIL FERTILITY

1. *Effect of ammonium chloride fertilizer on crop growth and soil*

Trials with ammonium chloride fertilizer were continued during the year with particular reference to the effect of chloride ion and sodium chloride.

In a pot experiment ammonium chloride alone @ 40 lb. N per acre increased the yield of wheat by 40 per cent. The response increased to 99 per cent. with 80 lb. N but further increase of fertilizer dose gave little additional response. The yields obtained with ammonium sulphate at the same rate of application were of similar magnitude and order. Under a treatment which included application of 300 lb. sodium chloride along with 200 lb. N as ammonium sulphate, the precentage increase in yield was 187 per cent. as compared to the increase of 110 per cent. with ammonium sulphate alone.

2. *Effect of application of ammonia in irrigation water on crop growth and soil*

The effect of application of ammonia in irrigation water was tested on paddy and wheat in small plot experiments, with ammonium sulphate as the standard fertilizer treatment. The response of both these fertilizers when applied @ 40 lb. N per acre was significant on paddy as well as wheat. The yield increases over control were as follows: Paddy—with ammonium sulphate—98 per cent; with ammonia—100 per cent and wheat—with ammonium sulphate—519 per cent; ammonia—369 per cent. The differences between ammonium sulphate and ammonia were not significant for paddy but were significant for wheat at 5 per cent level. Under laboratory conditions with 12 per cent moisture in soil, added ammonia was found to have lost 20 per cent nitrogen as compared to the loss of 6 per cent from ammonium sulphate. This may account for the somewhat inferior response observed on wheat.

3. *Cumulative effect of fertilizing with inorganic fertilizers, organic manure and mixture on yield and quality of wheat*

Under this experiment the seed for sowing is reserved from the yield of that treatment obtained in the previous year.

In the third year of the experiment, the yield and chemical composition of wheat under the three treatments showed no significant differences.

4. *Effect of pre-soaking seeds in nutrient solutions on growth and yield*

Pot experiments on wheat for the second year showed that pre-soaking of seeds for 15 hours in 5 per cent solution of different forms of nitrogenous fertilizers (ammonium sulphate, sodium nitrate and urea) and a mixed N.P. fertilizer like ammonium phosphate, has no beneficial effect on subsequent growth and yield. The experiment is now being modified.

5. *Comparative fertilizer value of dicalcium phosphate and superphosphate*

The experiment on paddy fertilized with dicalcium phosphate, superphosphate and bonemeal alone and in combination with inorganic nitrogen and F.Y.M. failed on account of failure of irrigation water.

The trial with subsequent berseem crop for residual effect was statistically significant. Significant increases in yield over control of 123 per cent with superphosphate and 87 per cent with dicalcium phosphate were obtained, indicating thereby that dicalcium phosphate is an efficient source of phosphorus for berseem. The response with dicalcium phosphate increased further to 116 per cent over control when applied in combination with F.Y.M. The differences between superphosphate and dicalcium phosphate alone or in combination with F.Y.M., however, were not significant.

Bonemeal alone showed no effect on berseem but in combination with F.Y.M. gave a significant increased yield of 107 per cent over control.

6. *Increasing the availability of phosphate by composting*

Prior treatment of superphosphate and crushed bones by adding the same to actively fermenting compost materials gives higher crop yield than a mixture of unfermented phosphate and an equivalent quantity of separately fermented compost. In the case of rock phosphate, however, there is no difference between a mixture of compost and rock-phosphate and fermented rock phosphate.

7. *The chemical composition of wheat plants as a guide for assessing its manurial requirements*

The experiment reported last year was continued in pots and fields with N.P. 718 and N.P. 165 varieties of wheat. Different levels of manurial dressings were given in order to bring about different levels of N and P_2O_5 concentrations in the plant at the 2-month growth stage. Samples of plants taken from the differently treated plots were analysed for N and P_2O_5 and based on these observations, suitable top dressings of fertilizers were given at the 2-month growth stage in order to test the effect of the above top dressings on the final yield of wheat.

The present series of experiments confirmed our earlier findings and showed that (a) chemical composition of the wheat plant at the jointing stages gives a good, indication of its nutritive level particularly in respect of N and P_2O_5 and (b) deficiencies of N and P_2O_5 revealed by the above analysis could be made good by suitable top dressings of fertilizers given at the jointing stage.

8. *Effect of continuous application of manures and fertilizers on the carbon and nitrogen levels of soils and their microbiological properties*

A study of the carbon and nitrogen content of soil samples taken from the long term manurial experiments proceeding at Pusa and Coimbatore showed that the application of F.Y.M. in doses varying from 4000 to 8000 lb. per acre increased the carbon content of the soil by 20 to 40 per cent over the unmanured check plots. There was no significant increase of carbon in the plots which received chemical fertilizers, mustard cake or green manuring. As regards the nitrogen level of the soil, none of the manurial treatments including F.Y.M., rapeseke, green manure or chemical fertilizers brought about any significant change in the nitrogen content of the surface soil. The soils examined in this study possessed C/N ratios narrower than 10 : 1.

The plots which had received annual application of F.Y.M. or compost showed higher bacterial counts, a higher rate of CO_2 evolution, higher azotobacter numbers and higher rate of nitrogen fixation in mannite medium as compared to the unmanured plots. The plots treated with chemical fertilizers showed higher ammonifying and nitrifying powers but lower azotobacter numbers and nitrogen fixing power than the plots treated with F.Y.M.

9. *Development of an economic plant and process for production of fuel gas and manure by anaerobic fermentation of cowdung and organic waste suitable for extensive adoption in villages*

A simple and efficient design of cowdung gas plant suitable for village homes was developed and six plants were set up in six different villages on an experimental basis. The plants worked satisfactorily during the year.

(*b*) MICROBIOLOGY

10. *Effect of inoculation with nitrogen fixing organisms on the yield of wheat, paddy and rahar*

There was no significant increase in the yields of wheat and paddy as a result of inoculation of the seeds and roots of crops with cultures of different nitrogen fixing organisms grown serially in medium containing extracts of respective plant materials. Increased yield of rahar was however observed when rahar seeds were inoculated with the root nodule organism, with Azotobacter from rahar leaves and with a mixture of the two.

11. *Activation of Azotobacter with and without cellulose decomposing organisms*

From a study of the nitrogen fixing capacities of Azotobacter isolated from different places in Mussorie Hills, it was observed that the nitrogen fixing capacity of the organism increased with increase in elevation. Nitrogen fixing capacities of some more strains isolated from other areas in the same locality are being determined to confirm the earlier observations. Azotobacter could not be detected in soils of some areas in the neighbourhood of Delhi.

12. *Studies on Rhizobium of wild leguminous plants*

Organism in the leaf gland of *Cassia occidentalis* was found to be a non-motile oval rod occurring singly and in pairs, aerobic, devoid of any capacity for fixation of nitrogen or formation of ammonia from proteins and capable of growing only in media containing combined nitrogen. The organism freely utilized nitrogen from inorganic nitrogenous materials. The organism was found to have some characteristics common with the strain of phosphorobacteria obtained from Czechoslovakia.

The organism in the outgrowth on the stem of *Aeschynomene aspera* appeared to be a weaker form of the organism in the root nodules of the same plant.

Leaf and root extracts of the non-nodulating legume *Cassia occidentalis* did they inhibit growth of rhizobia of common cultivated legumes. In some cases not exhibited definite stimulating effect.

There was evidence of nitrogen fixation by non-nodulating legumes, *Cassia occidentalis* and *Cassia angustifolia*. The water legume *Aeschynomene aspera* was observed to fix over 200 lb. of nitrogen per acre in Delhi soil.

There was a great deal of variation in the nitrogen contained in different wild legumes and it could be calculated that if they were turned under soil, they would contribute from 30 lb. to 948 lb. of nitrogen per acre.

13. *Studies on the relation between the efficiency of different strains of* Rhizobium japanicum*and their characteristics*

Eighteen strains of *Rhizobium japanicum* were isolated from five different types of nodules in the roots of the soybean plant differing in their size, position in the root, colour and texture. They were observed to be similar morphologically and in their relation to different strains. They were however differentiated from each other by marked differences in fermentation characteristics, acid tolerance and action on litmus milk. Production of slime by the strains was found to be somewhat related to the change in reaction they produced in sugar solutions.

14. *Effect of different indigenous phosphates on nitrogen fixation by guar*

Nitrogen fixation by guar was observed to be very much enhanced by application of superphosphate. Guar was not able to utilise indigenous phosphates like bonemeal, Singbhum phosphate, and Trichi nodules like pea or sunhemp to any appreciable extent. It was also observed that enhancement of nitrogen fixation by guar, as a result of treatment with superphosphate was very much higher when guar was grown in a poor soil than when grown in a rich soil.

15. *Nitrogen fixation in Indian soils in relation to phosphate availability*

From a study of nitrogen fixation in 20 soils from different parts of India carried out under different conditions, it was observed that nitrogen fixation in soils depended mainly on supply of phosphates and to a lesser extent on lime content and number of soil micro-organisms involved. Even under optimum conditions of supply of phosphates and lime, the soils differed in observed fixation of nitrogen which probably was also dependent on the nature of microbiological population in the soils themselves.

16. *Comparative study of the indicator plant method, Mitscherlich method and Neubauer's method for finding out mineral deficiencies in the soil*

Investigations with Delhi soil showed that the soil was dificiant in N and P_2O_5 the major deficiency being that of nitrogen. In the case of tomato crop, maximum yield of the fruit, and maximum %N and P_2O_5 were obtained with N_{175} P_{120} K_0 treatment in pot experiments.

17. *Microbiological decomposition of the herbicide, Methyl chlorophenoxy acetic acid (M.C.P.A.) in the soil*

M.C.P.A. at a concentration of 10 p.p.m. decomposed in 30 days in soil after the soil has been enriched with respect to the causative organisms by successive additions of M.C.P.A. of 2 and 5 p.p.m. concentration. However in liquid medium M.C.P.A. at a concentration of 5 p.p.m. took 150 days for decomposition. Aeration and surface area seem to play an important role.

18. *Effect of cations and anions on the rate of nitrogen fixation by azotobacter*

The optimum calcium requirement of the azotobacter isolated from Delhi soil was 10 mg. per 100 c.c. of medium. Optimum pH was observed to be 7·0. NO_3-N at a concentration of 1 mg. per 100 c.c. did not effect the nitrogen fixing power, but increasing doses of NO_3-N thereafter reduced this power.

B. SOIL SURVEY & SOIL PHYSICS

(*a*) Black Soils

19. *Genesis and nomenclature of Indian soils*

The black soils occurring on different parent rocks. *viz.*, basalts, mica-schists, limestone and granite were studied for their physical, chemical and minerological composition. Acid igneous rocks give rise to soils of good physical properties whereas soils from basic rocks possess favourable chemical characteristics that ensure abundant plant growth. Thus, although the black soils showed practically the same morphology, the differences of parent rocks are reflected in the soils and specially in the clays separated from them. Soil clays of basaltic origin contain montmorillonite while the clays from other soils contain besides montmorillonite some illite also. Two black soil profiles, Houston black clay and Tainter silty clay loam from U.S.A., were also studied for comparison. These soils belong to the group of " Grumosols " of Oakes and Thorpe, in which black soils of India are also included by them. The black soils of U.S.A. contain more organic matter and resemble our black or regur soils to a great extent.

(*b*) Laterites & red soils

The examination of several laterite profiles of the type area Angadipuram and laterite areas in Malabar and South Kanara districts of the West Coast lead to the conclusion that a maximum of seven horizons could occur in a single profile, although not all the horizons may exist in every place. Observations on the weathering sequence and profile development indicate that the iron compounds that separate out undergo changes from a diffuse pattern, to begin with, into vermicular,

vesicular or honey comb; slag like and pelletty or concretionary forms successively with advancing age and degree and intensity of profile development. Extension of field studies to regions in Cochin and Travancore revealed that the structure in the profiles is not well defined indicating restricted conditions of laterisation. Further biotite gneisses of the nearabout areas produced brown forest soils, while the syenites, diorites and charnockites invariably produced laterites. The deep red soils range from loam to somewhat heavy types and appear to be of alluvial origin.

Chemical analysis of laterites and the underlying parent rocks indicated that in laterisation apart from the losses of bases and silica, some amount of alumina has been invariably lost. Further a basic rock offers less resistance to laterisation than an acid type under similar climatic and other environmental conditions. The bulk of the evidence is in favour of adopting kaolinisation and laterisation as soil forming processes, treating laterite as a soil with well defined morphological features.

(*c*) Alluvial soils

The alluvial soils of Bahadurgarh and Ambala have been examined chiefly from the salinity point of view.

(*d*) Arid zone soils

The soils of Suratgarh Tehsil of Rajasthan showed heavy texture and prismatic to cloddy structure. The soils of the area may be grouped as paleo soils. Except where the salt and alkali are high, the normal soils are of potential value for agriculture, if water is available for irrigation.

20. *Soil surveys*

Reconnaissance soil surveys were carried out in the Community Project Centres, Sumerpur and Pisangaon. Sumerpur Centre of Rajasthan covers nearly 400 sq. miles. Geologically the area includes granites, schists and alluvium and the average rainfall is less than 25". Natural vegetation comprises scrub jungle of shrubs and grasses. The soils are classified into shallow soils over granites; reddish brown or chestnut brown soils; and dark coloured (black) soils with solonetzous characteristics.

In Pisangaon, Ajmer, the project covers an area of about 500 sq. miles, with an undulating topography—low hillocks, sand dunes and nallas. The surface rocks are mainly quartz and mica schists. The rainfall of the tract ranges between 25" to 30". In the plains the soils are deep and loamy sands in texture. In the rocky areas the soils are dark coloured sandy loams.

21. *Saline and alkali soils*

In the reclamation experiments on the farm area ploughing in of green manure crop helped in the leaching out of salts by the succeeding monsoon showers. Due to the high water table and lack of drainage the salts rise to the surface in the winter months. Artificial drainage along with application of gypsum to correct alkalinity has improved some of the plots. Applications of gypsum and organic refuse prior to monsoon rains have proved beneficial to crop growth and reduced the soil alkali in Delhi villages where crops are grown under rainfed conditions.

22. *Soil structure*

Krilium treatment produced 89 and 75 per cent of over 0·25 m.m. sized water stable aggregates respectively in clay loam and sandy loam soils. When these aggregates were crushed, passed through 0·25 m.m. sieve, wetted and dried the per cent aggregation reached the values 45 and 14 in clay loam and sandy loam soil respectively. Thus, the indications are that cultivation operations are likely to destroy the structural aggregates obtained by krilium treatment. The use of krilium in combination with gypsum helped in the development of good structure of saline and alkali soils under field conditions.

23. *Soil moisture*

In pot experiment using soils of different texture the optimum moisture for oat crop was found to be 8 to 10 per cent in sandy soil and 18 to 22 per cent in heavy loam soil. At optimum moisture content the pF values for all the texture grades studied remained at 2·9 to 3·0. In field experiment, grazed plots contained nearly twice as much moisture as in the cropped plots during summer months. Ley farming also increased the percentage of water stable aggregates in light loam soils.

C. PHYSICAL CHEMISTRY

24. *Studies on ionic changes in plants on bringing them into equilibrium with different ions with special reference to frost resistance in arhar*

Work done in collaboration with the Division of Botany has shown that the mean value of the specific electric conductivity of expressed juice of leaves of single plant selections of frost resistant varieties of arhar, P14.—NPC—38.UP—17—2 and P—48—1 was 3·92 millimhos at 19°C and was significantly higher at 0·1 per cent level than that of frost susceptible varieties EB—3. Guntur—2. C—11, T—84, F—18 whose value was 3·60 during the winter months. Corresponding value in 1 : 10 water extracts for the frost resistant variety BR—59 and the susceptible Ber-7 were 0·87 and 0·74, respectively. The value of the latter could be raised to 0·87 and 0·81 by fertilization with ammonium phosphate and sulphate nitrate of ammonia a month before the period of observation.

25. *Physico-chemical studies on the formation of the saline and alkali soils of Pusa and their reclamation*

The importance of making periodical observations on calcareous saline-alkali soils was shown by the work on Pusa soils. This indicated maximum alkali after the monsoon and again after the winter rains necessitating the addition of gypsum or super to keep up the soil permeability about the middle of these rainy periods. Periodical studies on the well water levels and their salinity have confirmed the previously proposed mechanism for the formation of these bad soils in this area and have shown the necessity to reverse the direction of natural flow of ground water besides providing adequate drainage.

26. *Studies on the anionic exchange capacity of soils*

The amount of anionically exchangeable phosphorus obtained from the Delhi soil using sodium bicarbonate at pH 8·5 was found to be a better index of plant absorption of P_2O_5 by wheat than that obtained by leaching the soil with sodium citrate whether at the pH of the soil or at 5·7. The soil phosphate potential, however, seemed to be a still more useful index than that obtained by sodium bicarbonate.

27. *Studies on clay-humus complex*

It was found earlier that the interaction of humus and inorganic components of the soil was dependent on SiO_2/Fe_2O_3 ratio of the clay, both in the red and black soils but to different extents depending on the soil colour group. By composting SiO_2, Al_2O_3 and Fe_2O_3 with F.Y.M. separately it was found that Tyulin's first group of clay-humus complexes characteristic of fertile soils was produced by SiO_2 in the clay, the second group by Fe_2O_3 and none of them by Al_2O_3. This shows the groups in the different soil clays and clay-minerals that are active in the production of the clay-humus complexes of varying fertility value.

28. *Studies on the interaction of soil clays and clay-minerals*

From measurements on the surface area, cation exchange capacity and moisture absorption of Karnal and Padegaon soils and bentonite both singly and in mixtures, it was found that while the mixture of Padegaon soil and bentonite had more or less additive properties, that of Karnal soil and bentonite showed significant departure from additive laws. This showed that the black soil which had montmorillonite as the dominent clay-mineral has no significant interaction with bentonite while the Karnal soil with illite and in the alkali conditions has a strong interaction with bentonite. In such cases, therefore, it will be difficult to judge the properties of soil clays which are usually mixtures of different groups of clay-minerals even if the mineralogical composition of these soil clays is known.

D. PLANT CHEMISTRY

(a) Organic Chemistry

29. *Organic thiocyanates*

Larger samples of longifolyl thiocyano-acetate, propyl-thiocyano-acetate, isobornyl-thiocyano-acetate and beta-thiocyano-ethyl ether of terpineol are being prepared. The samples will be submitted to National Research Development Corporation for assessing them as economic insecticides.

30. *Synergists for insecticides and insecticidal formulations*

The yields of terpene ethers and alcohols, while using terpentine oils obtained from Himachal Pradesh, Rosin and Terpentine Factory, Nahan and Rosin and Terpentine Factory, Jammu, were lower than those obtained from terpentine oil, from Northern India Rosin and Terpentine Factory, Bareilly earlier. These oils were also found to have different physical constants as compared to Bareilly oil. This suggests a need of process control in the production of terpentine oil to be used as a raw material for the preparation of terpene ethers and alcohols.

31. *Fungicides—Organic Mercurials*

The adducts of longifolene and camphene, with mercuric acetate and their subsequent conversion into stable chloro, bromo and iodo derivatives, were studied further, these derivatives have now been isolated, in yields of 60—65 per cent in case of camphene and 50—55 per cent in case of longifolene.

32. *Pyrethrum*

In connection with the assay of pyrethrin I & II in the flowers, it has been found that cold percolation gives yields of pyrethrins, which compare favourably with Soxhlet extraction. The results are being examined further.

33. *Biogenesis of Fat during ripening of seeds*

A new technique has been developed to determine the saturated acid content in small amount of mixed fatty acids by acetic acid-acetone-permanganate oxidation and Bertram separation of oxidation products.

34. *Studies on soil organic matter*

With a view to determine the fertility status of Indian soils by finding out the various functions of the effect of different factors, such as temperature, diurnal variation in temperature, barometric pressure, rainfall, altitude, topography, longitude and latitude (location), microbiological population, three hundred and fifty samples collected earlier were analysed for organic carbon by dry combustion and inorganic carbon by Collins calcimeter. Nitrogen estimations were carried out by Soil Microbiology Section. The results obtained are being statistically examined for evaluation of multiple regression.

It was also observed that the extent to which carbonate carbon is present, has an important bearing upon the recovery of carbon by wet combustion and subsequent factor to be employed for the determination of organic carbon.

(b) Biochemistry

35. *Chemical composition and nutritive value of maize as affected by manures and fertilizers*

Maize grains grown with different manures and fertilizers were analysed for their chemical composition including vitamins and amino acids.

FYM, N, K, NK and NP treatments seem to have increased the protein content while P and PK treatments have reduced it. The content of protein varied from 9·31 per cent to 11·87 per cent.

The application of superphosphate either alone or in combination (P, PK, NP and NPK) significantly increased the P content of the grain, 70 to 90 per cent of the total phosphorus being in the form of phytin-phosphorus.

Phosphatic fertilizers alone or in combination with other fertilizers (P, PK, NP, NPK) have been found to have increased the thiamine content of the grains. Niacin and riboflavin contents were not much affected by the treatments. Amino acids (methionine, cystine and tryptophane) were also unaffected by manurial treatments.

36. *Quality of wheat as affected by the spraying of urea solution*

Experiments carried out in the field to study the effect of foliar application of urea on wheat showed that the spraying of as low as one per cent urea at the time of flowering significantly increased the yield and protein content of the grains. The maximum increase (32 per cent) in the protein content of wheat was obtained when 6 per cent urea was sprayed thrice, the increase being chiefly due to that of true protein. Urea spraying also increaseed the 1000-kernel weight and caused a highly significant reduction in the percentage of mottled grains.

37. *Quality of wheat as affected by micro-element fertilizers*

Field experiments conducted for three years have shown that copper, manganese, zinc and magnesium whether applied singly or in combination to Delhi soil significantly increased the yield of wheat. This increase was from 12 to 30 per cent, the maximum being with manganese. Foliar application of copper, zinc and magnesium also increased the yield of wheat grains, the maximum increase (19 per cent) being with magnesium.

Manganese and zinc when applied to the soil significantly increased the protein content of the grains, the maximum being with manganese. Foliar application of copper, zinc and magnesium also increased the protein content of the grains, the maximum being with zinc in this case.

It is of interest to note that with no basal dressing of NPK foliar application of a mixture of micronutrients greatly increased the protein content of the grains. Such increase was less pronounced when the soil was given a basal dressing of NPK.

38. *Enzymic digestibility of pulse proteins*

The enzymic digestibility of pulse proteins was studied with pancreatin. Cooked pulses were incubated at pH 8·3 at 37° C in the presence of pancreatin and the rate of hydrolysis was measured by formol titration. The percentage of enzymic digestibility as compared to acid hydrolysis of the same was found to be about 65 per cent. The amino acids of the pulse proteins released by the acid hydrolysis as well as by pancreatin were determined by the paper partition chromatography.

39. *Excretion of free amino acids in the soil by legumes*

Further studies on the excretion of free amino acids in the soil by berseem crop confirmed the findings reported last year. Soil from the no manure plot growing berseem was found to contain aspartic acid, glutamic acid, asparagine, leucines and valine (and methionine) whereas in the soil from the fallow plot none of these amino acids except traces of cystine and leucine could be detected. The soil from the phosphate treated plot growing berseem was found to contain arginine in addition to other amino acids mentioned above. Soil from an adjoining wheat field on the other hand was found to contain no free amino acids.

40. *Nutritional requirements of Lactibacillus leichmannii*

In an attempt to simplify the composition of the medium for the growth of *Lactobacillus leichmannii* required for the estimation of vitamin B_{12}, it was found that 15 amino acids could support good growth, alanine being indispensible for this organism. Among the vitamnis calcium pantothenate and niacin are essential while pyridoxine and folic acid are stimulatory. Uracil is also required partially.

41. *Biosynthesis of vitamin B_{12}*

The synthesis of vitamin B_{12} by certain organisms was studied. Azotobacter was found to synthesise this vitamin to a considerable extent. The effect of different substances on the synthesis of Vitamin B_{12} was also studied. It was found the Vitamins B_1, B_2, para amino-benzoic acid and methionine helped in the synthesis of Vitamin B_{12}.

42. *Chemical composition and nutritive value of wheat*

Samples of wheat grown in replicated plots at New Delhi, Karnal and Pusa (Bihar) were analysed for their chemical composition. On an average total phosphorous, phytin-P and weight of 100 grains were high in samples grown at New Delhi than those grown at Pusa. While reverse was true in respect of protein, calcium, diastatic activity and niacin content.

Chapati making trials were also conducted and considerable differences were found in the water absorption capacity and *chapati* making quality of the different varieties of wheat tested.

E. PHYSICS

43. *Quantitative estimation of micro-elements in citrus leaves by Copper Arc Method*

Copper Arc Method of estimating micro-elements in soils was developed last year in this laboratory. The method not only worked out to be quite economical but also proved to be sensitive enough for the estimation of B, Mn and Zn.

The average major element compositions of citrus leaf was taken from the data collected in this laboratory by Lundegärdh spectrographic technique as well as from the data recorded abroad by other investigators. Using—synthetic citrus ash prepared from spec-pure chemicals, working curves were drawn for B, Mn and Zn. Recoveries obtained using the working curves were very satisfactory and the duplicates recorded were quite close in their values. The results obtained by spectrographic method were compared with those obtained by chemical method and the agreement was found to be within 10 per cent difference.

44. *Estimation of zinc by Polarographic Method*

Cambridge pen recording polarograph was set up and was standardised with cadmium solution. The method of estimation of Zn in soils and plant meterials developed by Stout and co-workers was slightly modified as to suit the limits of Zn content in the citrus leaves grown in India. It is possible with the technique

developed to estimate Zn down to 1 p.p.m. in citrus leaves on dry matter basis. The results obtained by the polarographic method were compared with those obtained by chemical method. The agreement is very close and the deviations are usually within 10—15 per cent when Zn content of the order of 1—5 p.p.m. was estimated. This method is now being used for the analysis of Zn in plant meterials.

45. *Major and micro-element status of citrus leaf collected at different periods of growth in the I.A.R.I. Orchard.*

Citrus leaf collected from labelled plants of grape fruit, Malta and Santra on twelve different dates during the plant growth in 1955-56 were analysed for B, Mn, Cu, Zn, Mo, K, Ca and Mg, with a view to understand the status of these elements in healthy and diseased plants and the variation in their composition if any with growth. Analyses were made using spectrographic, polarographic and chemical methods. The results broadly indicate significant differences in major element status between the healthy and the diseased plant samples. The data is under scrutiny.

46. *Micro-element uptake of feeds, fodders & crops*

In the earlier work done in this laboratory on the influence of Molybdenum on the growth and yield of berseem, a dosage of 2 lb. Mo was given. On the field experiment conducted at Nagpur, however, dosages ranging from 2 oz. to 2 lb. per acre were given. Amongst these different dosages, 8 oz. dosage of Mo O_3 particularly and in general dosages between 4 oz. to 1 lb. showed better yields than a dosage of 2 lb. given. In view of this experience, in the pot experiment conducted this year using Broach and Surat black cotton soils, two dosages of Mo, 2 lb. and 1 lb. were tried. The total yield of berseem in Surat soil both at 40 lb. and 80 lb. level of P_2O_5 showed definite increase in yield only at 1 lb./acre dosage of Mo. The yields of control, 40 lb . P_2O_5 and 40 lb. P_2O_3 and 1 lb. MoO_3 being 85·6 gms., 199·6 gms. and 231·6 gms. respectively while with 2 lb. of MoO_3, the yield was 193·1 gms. At 80 lb. level of P_2O_5 the yields recorded for control, 80 lb. P_2O_5 and 1 lb. MoO_3 treatments were 85·6 gms., 252·7 gms. and 309·9 gms. while with 2 lb. MoO_3 the yield was only 273·6 gms. On the Broach soil, however, the response of Mo though slight cannot be taken as definite.

F. (a) SOIL TESTING & SOIL CORRELATION

47. *Estimation of available nitrogen in soils by different methods and correlations with crop responses*

The work on the relative merits of different methods of estimation of available nitrogen as judged by their comparative correlation capacities with crop responses were continued. The correlation coefficients as obtained with three methods of estimating available nitrogen, namely—(1) alkaline permanganate method (0·32 per cent $KMNO_4$+2·5 per cent alkali), rapid Iowa nitrification technique and Olsen's method indicate that alkaline permanganate method gave significant correlation on paddy, wheat and Bajra in a good number of soils. The Iowa nitrification method gave significant correlation only with wheat crop and not paddy and the Olsen's method did not give any significant correlation with any crop.

48. *Determination of available potassium by different methods and correlation with crop responses*

The work on the estimation of available potassium by different methods for selecting a suitable method or methods which give significant correlations with crop responses to potassic fertilizers. The six methods, namely, (1) 1 per cent citric acid, (2) normal ammonium acetate, (3) Morgan's extractant, (4) 0·5N HNO_3 (1 hour heating), (5) 0·5N HNO_3 ($\frac{1}{2}$ hour shaking) and (6) per cent K saturation were compared for their relative correlating capacities in different soils.

The results indicate that the Morgan's extractant gave significant correlation with crop response in red and lateritic soils while in alluvial soils nitric acid gave better correlation. No method was found to give any significant correlation for all the types of soils.

49. *Preparation of soil test summaries and assessment of the fertility status of community project areas and Delhi State villages*

500 soils have been analysed for different constituents like pH, conductivity, organic carbon, available nitrogen, available phosphate and available potash for the assessment of the fertility status of the following community project areas: (1) Alipur (Delhi), (2) Dumka (Bihar), (3) Arkisolan (Simla), (4) Nabha (Pepsu), (5) Kalhandi (Orissa), (6) Mangalore (Madras), (7) Nilokheri (Punjab), (8) Alwaye (Travancore and Cochin), (9) Pesangaj (Ajmer).

Soil fertility maps of Alipur Community Project Area showing the distribution of the available nutrients, namely, nitrogen, phosphorus and potassium and other constituents like organic matter, soil reaction and soluble salts have been prepared. In this area, soils are alkaline and out of these 3 per cent have pH above 8·7 and require reclamation, 24 per cent of the soils are saline to varying degrees. The carbon content is low in 83 per cent of the soils and medium in 17 per cent. In 4 per cent of the soils, the salt content is critical and 9 per cent of the cases, the salt content is harmful. The available nitrogen is medium in 1·3 per cent of the soils and is low in the rest 87 per cent. Available phosphate is high in 10 per cent of the soils, medium in 36 per cent and low in 54 per cent. Available potassium is high in 8 per cent of the soils, medium in 25 per cent and low in 46 per cent.

Soil test fertility maps and summary tables have been prepared for Qamaruddin Nagar Village (about 400 acres area) on the basis of 82 soils collected at the rate of one sample per acre for every 5 acres. All the soils have pH about 7·0 and 6 per cent are alkaline soils requiring reclamation measures. 15 per cent of the soils are saline to varying degrees, practically all the soils are low in organic matter content. The available phosphate is high in 1 per cent, medium in 68 per cent and low in 31 per cent of the soils. The available potassium is high in 9 per cent of the soils, medium in 39 per cent and low in 52 per cent of the soils. 49 fertilizer experiments on the basis of the soil test have been laid out in *Kharif*, 1956 (Bajra & Jowar Crops).

50. *Examination of suitability of four soil test kits for rapid soil test work*

This I.C.A.R. Scheme came into operation from March, 1956 at six centres, namely, (1) Delhi, (2) Kanpur, (3) Sabour, (4) Nagpur, (5) Poona and (6) Coimbatore with the object of comparing the suitability of the four kits namely (1) Morgan's

soil testing system, (2) Spurway's soil testing system, (3) Purdue soil test kit and (4) soil test kit prepared at I.A.R.I. in indicating the status of the constituents, namely, pH, available phosphate and available potash as judged by crop responses to fertilizers.

Some preliminary work on the development of suitable indicators for pH and a rapid procedure for organic carbon in soils was made. A combination of indicators phenol red, alizarine red (S) and thymol blue has been prepared and found to give distinctly different colours at a maximum difference of 0·5 pH on the alkaline side. The values are found totally well with the electrical method. This is likely to be particularly useful in soil test kits of our country where one of the main problems is infertility arising from the excessive alkalinity in some of the irrigated areas. A rapid soil test kit procedure for the estimation of organic carbon in soils having a wide variation, in its content has been developed using sulphuric acid and potassium dichromate.

51. *Determination of manurial needs by tissue tests*

The work on the standardisation of tests for determining the manurial requirements of wheat and paddy was continued. Tissue tests for nitrogen and phosphorus on paddy (NP 130) having the treatments, (1) control, (2) control plus lime (3) control plus lime plus basal dose of all elements except potash, (4) control plus lime plus basal dose of all except nitrogen, (5) control plus lime plus basal dose, (6) control plus lime plus basal dose of all with 100 lbs. K_2O were conducted on leaves and stems after 2 months of transplantation. The data indicate a moderate correlation with the yield of the whole crop.

F. (b) RADIO-TRACER INVESTIGATIONS

52. *Phosphorus fertility status of soils, radiotracer and related investigations*

(a) AVAILABLE PHOSPHORUS IN SOILS & PHOSPHORUS FERTILIZER UTILIZATION BY RICE AND WHEAT

31 different soils were brought from various regions in the country and rice on 20 soils and wheat on 11 soils were grown in green house with 0, 40, 80 and 160 lb. P_2O_5/acre applied as radioactive superphosphate over a basal dose of all other nutrients at suitable levels. There were four replications. The crops were harvested when they came to ears. At harvest number of tillers and yield of dry matter were recorded. The crops were then analysed for total phosphorus, radioactive phosphorus, total nitrogen and total potassium. The soils were analysed for moisture equivalent, pH, calcium carbonate, total nitrogen and available phosphorus. From the plant analysis data percentage of phosphorus in the plant derived from the fertilizer and that from the soil, per cent of the applied fertilizer actually utilized by the crop and 'A' values were calculated.

It was found that in both, the crops response to phosphorus was very marked in about 60 per cent of the soils used. The response curve was of the usual type and was found to flatten out between 80 and 160 lbs. P_2O_5/acre dose. The percentage of the applied fertilizer utilized by wheat varied from 8·5 to 20·7 while that for paddy from 2 to 22·7. It is important to note how little of the applied fertilizer

was actually utilized by the crops. It was found that the percentage unsaturation of the anion exchange complex of the soil in respect of phosphorus had a definite relation with the percentage P_2O_5 from the applied fertilizer utilized by the crop. The coefficient of correlation for soils under paddy was r=-0·946 and for soils under wheat r=0·950. The calculated 'A' value, from the formula $A = B\left(\frac{1-Y}{Y}\right)$ where A is available phosphorus, B is the applied P_2O_5 in lbs. from fertilizer and Y is the fraction of the nutrient in the plant derived from the fertilizer, was found to correlate well with the available phosphorus as determined by the Olsen method.

(b) MEASUREMENT OF SURFACE PHOSPHORUS OF SOILS—ISOTOPIC EXCHANGE WITH RADIOPHOSPHORUS

Equilibriation curve of P^{32} with surface phosphorus (P^{31}) was determined for a number of soils used in pot culture work with rice or wheat. An attempt was made to resolve the curve into two parts representing broadly two types of reactions in the process of equilibriation. The surface phosphorus as calculated from the value at the transition point did not correlate significantly with 'A' value. An arbitrary 60 hour period was chosen as suggested by " Black *et al* " and the surface phosphorus calculated from the value at this point was found to correlate significantly with 'A' value (for 13 soils r=+0·798) and the available phosphorus by $NaHCO_3$ method (for 21 soils r=+0·771). This substantiates Olsen's method for $NaHCO_3$ extraction as well as the theory that residual phosphate in slightly alkaline to neutral soils is mostly present as surface phosphate.

It is found however, that the behaviour of our soils, so far as the nature of equilibriation curve suggests, is quite different from that reported on U.S. soils.

(c) PLACEMENT STUDIES ON PHOSPHORUS FOR WHEAT AND RICE-POT AND SMALL PLOT EXPERIMENTS WITH TAGGED MATERIAL

Small plot (1 sq. yd.) trials were conducted on paddy (Var. NP 130) at I.A.R.I., New Delhi. Radioactive superphosphate tagged at a level of 0·15 mc./g P_2O_5 was applied at the rate of 40 lb. P_2O_5/acre as (i) surface broadcast, (ii) placed in the form of pellets under the seed at 3″ below the surface and (iii) placed in the form of pellets under the seed at 6″ below the surface. A basal dose of 80 lb. N/acre and 40 lb. K_2O/acre was applied to all the plots. There were four replications and the various treatments were randomized according to the randomized block layout. Though no significant increase in yield was observed due to phosphate fertilization under any treatment it was interesting to note that maximum utilization of phosphatic fertilizer occurred from the surface broadcast application of the phosphate (surface broadcast—35·67 per cent, placed at 3 per cent depth—20·4 per cent, placed at 6″ depth—16·01 per cent). The experiment is being repeated on a much larger scale this year. An experiment on placement on wheat (NP 718) was also conducted at the farm in which phosphate applied as (i) surface broadcast was compared with, (ii) that placed at 2½″ below the seed row and (iii) that placed at seed level, 2½″ away on both sides of the seed row. Record of yield data showed a response to phosphate but no significant difference among the various phosphate treatments. Further data are under compilation.

(d) FIXATION, EXCHANGE AND MOVEMENT OF PHOSPHORUS IN SOILS

For getting autographic record of movement and fixation of phosphorus in soils, a sectioning technique of soil columns was developed and downward movement of phosphorus in 13 soils at 40 and 160 lb. P_2O_5/acre doses was followed. Movement of phosphorus was found to be very restricted ranging from 0·25″ to about 1 inch at 40 lb. P_2O_5/acre dose. At the higher dose movement naturally was more but no definite relation with depth through which the phosphorus moved and concentration of phosphate solution used was discernible.

Influence of organic matter on fixation and movement is under study on a number of soils.

In 31 soils used in pot culture work, anion exchange capacity and exchangeable phosphate were determined in an effort to determine relation between uptake of phosphorus and unsaturation.

(e) CORRELATION OF SEVERAL SOIL PHOSPHORUS TESTS WITH WHEAT AND PADDY CROP RESPONSES

In continuation of our efforts in the past year to develop a suitable soil test for phosphorus, different methods were given further trial on soil samples collected from (a) pot culture experiments and (b) TCM agronomic trials and data correlated with yield responses.

It was found again that the $NaHCO_3$ method was the best so far as the correlation with yield responses was concerned. The correlation coefficients for paddy on 20 soils with this method was 0·855 and that for wheat on 11 soils was 0·754 both of which are significant at 1 per cent level. If the soil analyses less than 20 lb. P_2O_5/acre by this method—phosphate fertilization will increase the yield.

A new method for estimation of available phosphorus of soils was developed which utilizes 0·075 per cent versene solution with 0·03 N NH_4F added. 2·5 g. soil was shaken with 25 cc. of solution for 15 minutes. The results were correlated with yield responses. The method was found to give highly significant correlation with yield responses to phosphorus fertilization.

The coefficient of correlation for 12 soils under wheat was 0·808, for another 11 soils under wheat—0·897, for 18 soils under paddy 0·681 and another 20 soils under paddy 0·851. The method is of great significance as it is better than the $NaHCO_3$ method in many respects.

(f) COMPARATIVE EFFICIENCY OF DIFFERENT PHOSPHATIC FERTILIZERS THROUGH RADIOTRACER STUDIES FOR WHEAT AND RICE ON MAJOR INDIAN SOILS :

A study of the methods of production of different phosphatic fertilizers, *e.g.*, superphosphate, ammoniated superphosphate, monocalcium-phosphate, dicalcium phosphate, monoammonium phosphate, diammonium phosphate and calcium metaphosphate in the laboratory was made with a view to select the most suitable method of tagging. The study was completed and the above fertilizers were prepared tagged with P^{32} at a level of 0·15 mc/g P_2O_5.

(g) PHOSPHORUS STATUS OF MAJOR INDIAN SOILS-EFFECT OF FLOODING, ORGANIC MATTER AND CATIONS

Soil samples collected from various parts of India so as to represent major soil groups were analysed for total, HCl soluble organic and available P_2O_5. Total and HCl soluble phosphorus showed a wide variation ranging from 228—

1189 p.p.m. and 211—982 p.p.m. respectively. Organic phosphorus n Kashmir soil was as high as 439 p.p.m. and constituted 40 per cent of total P_2O_5 while the samples from Rajasthan had only 32 p.p.m. organic phosphorus.

Laterite soils showed as little as 1·7 lbs. P_2O_5/acre available phosphorus.

Application of F.Y.M. so as to give 80 lb. N/acre increased available P_2O_5 by 5 to 40 per cent as compared to untreated samples. Flooding the soils increased the available P_2O_5 in most cases accompanied by a decrease in pH.

F. (c) CARTOGRAPHY

53. *Research on mapping of drainage*

Drainage on soil maps is divided into following types : streams, lakes and ponds, springs, sinks, alluvial fans, rapids and falls, marshes, ditches, canals, gulleys and fore-shore features. The specific mapping procedures for the drainage have been laid down. All drainage work on soil survey maps have to conform to the degree of accuracy and standard of quality laid for these symbols. Photo-lithographic specifications of these symbols for the preparation of map manuscripts on 1/20,000 and 1/40,000 scale and reproduction on the sacle of 1″ to one mile have also been determined. Every physiographic feature under drainage is listed and described. This glossary and specifications have been compiled as an aid to the soil surveyor in determining appropriations and correct delineation of a drainage feature.

54. *Research on basic soil regions*

A land classification based on fundamental characteristics of the land, supplies a basis for drawing conclusions regarding the use of land for more than one purpose, so that the result of research carried on in one region can be safely applied to the areas having similar innate characteristics. The character of the soil in early stages of its formation is determined to a great degree by the character of the parent rock, whereas in its later stages of development by the impact of climate and vegetation. On the basis of this hypothesis, India is first divided into areas of different steepness. To start with, the arid belt covering Rajasthan, Saurashtra, Madhya Bharat is taken for steepness analysis. The region is divided into the following categories : (i) 1·864 per cent, (ii) 3·728 per cent, (iii) 5·591 per cent, (iv) 7·456 per cent and (v) 11·338 per cent on the basis of contours. This gives a vivid picture of relative relief of land in the plains, plateaus and hilly areas of Rajasthan, Madhya Bharat and Saurashtra. This map has been completed. Steepness of slope is a very important land property because it affects the amount and rate of erosion, the application of irrigation water, the use of machinery and the general management and treatment of land. Therefore this map will prove of paramount importance to soil conservation work in this region.

Regarding the preparation of soil maps in the scheme, no soil map is yet finalized to the extent that it could be taken for cartographic analysis and reproduction.

Training of Post-Graduate students was undertaken in Cartography and Topographical surveys.

PROGRAMME OF WORK FOR 1956-57

A. Agricultural Chemistry

(a) *Soil Fertility*

1. Fertilizer response in respect to yield of crop and uptake of nutrients.
2. Effect of dipping roots of paddy seedlings in fertilizer solution before transplanting on growth and yield of paddy.
3. Effect of soaking seed of wheat and maize in fertilizer solutions on, growth and yield.
4. Standardisation of the method of determination of manurial requirement of wheat and maize by the tissue tests.
5. Comparative study of the indicator plant method, Mitscharlich method and Neubaur's method for finding out the major nutrient deficiencies in black soils.
6. Increasing availability of phosphate by composting.
7. Effect of continuous use of organic manure (FYM) and inorganic fertilizers and their combinations on the quality of wheat.
8. The chemical composition of the wheat plant as guide for assessing its manurial requirement.
9. Supplement of the ICAR Scheme on Examination of rapid method of soil test for Soil Survey Work.
10. Development of an economic plant and process for production of fuel gas and manure by anaerobic fermentation of Cowdung and organic-wastes suitable for extensive adoption in the villages.
11. Manurial value of spent slurry from Cowdung gas plant.
12. Effect of inoculation with nitrogen fixing organisms on the yield of wheat and paddy and arhar.
13. Activation of azotobacter with and without cellulose decomposing organisms.

(b) *Soil microbiology*

14. Studies on Rhizobium of wild leguminous plants.
15. Microbiological decomposition of herbicides (M.C.P.A.)
16. Studies on the relation between the efficiency of different strains of Rhizobium japanicum and their characteristics.
17. Effect of different indigenous phosphates in nitrogen fixation by *Guar*.
18. Effect of cations and anions on the rate of nitrogen fixation by Azotobacter.
19. Role of soil reaction on the availability of plant nutrients in soils.
20. Nitrogen fixation in Indian soils in relation to phosphate availability.

B. Soils Survey and soil Physics

1. Genesis, standardisation of taxonomic units and nomenclature of Indian Soils.
2. Mineralogical studies of parent materials.
3. Survey and mapping of Delhi State soils.

4. Studies on saline and alkaline soils and well waters.
5. Studies on soil structure.
6. Soil—moisture studies.
7. Soil fertility and fertility status of Indian Soils.
8. Scheme for the collection and collation of the Soil Survey data in India.
9. Study of the properties and formation of black soils as affected by parent rocks.
10. Studies of soil at different altitudes of Kashmir State.
11. Studies on laterites and related soil of the West Coast.

C. Physical Chemistry

1. Studies on the ionic exchanges in soils, clays and clay minerals and plant roots.
2. Electro-kinetic properties of aluminosilicate precipitates, clay minerals and soils in relation to formation of clay minerals.
3. Minerological studies of soils and clays.
4. Studies on the separation and properties of clays and clay-humus complexes from soils.
5. Studies with interaction of clays and clay minerals and their significance on the determination of the minerological composition of clay.

D. Plant Chemistry

(a) *Organic Chemistry*

1. Preparation of synthetic pesticides.
2. Preparation of insecticides from natural sources.
3. Biogenesis of fats in plants during the ripening of linseed and mustard seed.
4. Carbon and Nitrogen status of soils in relation to soil fertility.
5. Development of antioxidants for edible oils and fats.
6. Co-ordinated scheme for the improvement of essential oils.
7. Synergists and insecticidal formulations based on indigenous materials.
8. Fungicides.

(b) *Biochemistry*

9. Nutritive value of crops as affected by manurial, cultural and storage factors.
10. Studies on soil metabolizm.
11. Oxidation—reduction systems in the plant.
12. Mechanizm of synthesis of amino acids in the plant.
13. I.C.A.R. Scheme on the chemical composition and Nutritive value of Indian wheat.
14. Quality of wheat as affected by spraying of urea.
15. Quality of wheat as affected by micro-element fertilizers.
16. Amino acid make up of plant proteins.

E. Physics

1. Spectiographic methods of analysis of soils and plants.
2. Study of the micro-element status of Indian soils.
3. Studies on the micio-element uptake of plants in relation to the nutritive value of grasses, forages, etc.
4. Co-ordinated scheme for the investigation of micro-nutrients.
5. Study of the physical properties of purified preparations of plant viruses.
6. Study of Indian clays.

F(a) Soil Testing Service and Soil Correlation

1. Determination of available nitrogen.
2. Correlation of several soil phosphorus and available phosphorus in soil for the preparation of manurial schedule.
3. Determination of available potassium and correlation with paddy crop responses.
4. Soil Test Summaries and assessment of fertility status of Community Project Area and Delhi State.
5. Organic carbon and nitrogen status.
6. Soil conservation studies.
7. Soil Correlation (All India Soil Survey Scheme).

F(b) Radiotracer Investigations

1. Available phosphorus in soils and phosphorus fertilizer utilization by rice, wheat, oats—a green house cum laboratory study with radio-active superphosphate.
2. Measurement of surface phosphorus of soils—isotopic exchange with radio-active phosphorus.
3. Placement studies in phosphorus for wheat and rice—pot and small plot experiments with tagged material.
4. Fixation, exchange, and movement of tagged phosphorus in soils.
5. Correlation of several soil phosphorus tests with wheat and paddy crop responses.
6. Comparative efficiency of different phosphatic fertilizers through radio-tracer studies for wheat and rice on major Indian soils.
7. Phosphorus status of major Indian soils—effect of flooding organic matter and cations.

F(c) Cartography

1. Preparation of basic soil region maps.
2. Compilation and preparation of maps from Soil Survey Data and Soil Test Summaries.
3. Standardisation of symbols and procedures for compilation of soil map.

REPORT OF THE DIVISION OF ENTOMOLOGY

(Dr. E. S. Narayanan)

General

(A) National Pusa Collection

(*a*) *Receipt of Insects for identification.*—45 lots of insect specimens belonging to almost all major insect orders were received for identification from different correspondents.

(*b*) *Insects sent to outside specialists for identification.*—141 insect specimens were sent out to the Commonwealth Institute of Entomology, London, and the Zoological Survey of India, Calcutta. Of these, the 16 specimens of Pyrrocoridae sent to Calcutta have been received back after due identification and incorporated in the N.P.C. The identifications from London are awaited.

(*c*) *Donations made from N.P.C.*—148 named insect specimens were sent out as donations to seven organisations or individuals and 48 undetermined diopsid flies for study to Paul Ardo, Esq., of the University Zoology Institute, Lund, Sweden.

(*d*) *Donations received for N.P.C.*—8 lots of insect specimens, partly named and partly unnamed, for studies here, comprising 98 insects were received for incorporation in the N.P.C.

(B) Advisory

About 450 insect specimens received for identification from various correspondents were duly identified and the identifications communicated to them. Insect specimens were also returned in cases specially asked for. Suggestions on control of pests and infestation by different insect species were communicated to various correspondents.

(C) Delhi Intensive Cultivation Scheme

The staff of the Division continued to survey the crop pests and demonstrate the control of major pests. Control measures were carried out against *Aulacophora foveicollis* infesting 5·25 acres of cucurbits, *Amsacta moorei* and *Chilo zonellus* infesting about 23 acres of maize, termites and borers infesting about 3 acres of sugarcane, *Leptocorisa varicornis* infesting about 8 acres of paddy and the singhara beetle infesting about 10 acres of waterunt. 16068 rat holes and an additional area of 9·2 acres infested with rats were also treated suitably.

II. RESEARCH PROJECTS

Systematic Entomology

(1) *The Taxonomy of Indian Curculionidae.*—A catalogue of the sub-family Otiorrhynchinae of the oriental region has been under compilation.

(2) *Taxonomy of Indian Vespinae.*– Studies on the male genitalia of identified specimens of Vespinae in the N. P. C. were continued. The studies indicated that the two genera—*Vespa* and *Polistes* are easily separable on genitalic characters. Intra-specific differences in genitalic structures were observed.

(3) *Taxonomy of Indian Aeshnidae.*—The preparation of the review of the genitalia in Odonata was taken up. Suitable mounts of different genera belonging to the family Aeshnidae were prepared.

(4) *Studies on the Terminalia of Indian Coccinellidae.*—Collection and preparation of the review of the family has been completed. The studies on the genital character reveal that they are of definite taxonomic importance.

(5) *Studies on Indian Ichneumonidae.*—Cataloguing of the tribes Mesostanini of the sub-family Gelinae and tribes Joppini and Amblyteline of the sub-family Ichneumoninae were completed. Cataloguing of the tribes Phaeogenini and Ichneumonini were teken up.

(6) *Revision of the Chalcididae.*—The existing literature on the sub-family Haltichelliane was under compilation.

Besides the above, work on the revision of the sub-families Oedipodinae and Acridinae on the basis of their genital characters was completed. Work on the classification and cataloguing of the family Asilidae (Diptera) was completed and a catalogue was sent for publication.

INSECT PARASITOLOGY

(A) Fundamental Studies

I. *Survey of parasites and predators of insect pests.*—The eulophid parasite recorded on the citrus leaf miner, *Phyllocnistis citrella* was identified as *Ametellon* sp. The female lays only one egg on a fully developed host. At the laboratory temperature and humidity the incubation period, the larval period and the pupal period were 6 to 10 hours, 4 days and 6 days respectively. The entire development is completed in 9-11 days. The females lived for 24 to 30 hours. A chalcid parasite hitherto unrecorded was reared from the pupae of citrus *Psylla.* A chalcid and a braconid parasite were bred from the cotton leaf roller, *Sylepta derogata.*

II. *Effect of nutrition on the fecundity, longevity and sex ratio of Bracon gelechiae Ashmead and Trichogramma evanescens minutum Riley using Corcyra cephalonica St. as their host, fed on various synthetic diets.*

(i) *Effect of food on larval instars of Corcyra.*–The number of instars in jowar, jowar+20% groundnut and jowar+4% yeast were generally 7, 6 and 7 respectively. The total larval periods were 35, 34 and 33·2 days respectively in the above mixtures.

(ii) *Effect of food on the larval growth of Corcyra.*—The sequence of diets as indicated by the development of *Corcyra* larvae was tentatively of the order: (jowar+riboflavin @ 12 or 24 micrograms/gm of diet)> (jowar+nicotinic acid @ 15 micograms/gm of diet)> jowar = (jowar+20% casein)> (jowar 2= cholesterol)> total synthetic diet (containing starch, 80 parts+casein, 20 parts+cholesterol, 1 part and Mc Collum's salt mixture, 2 parts+vitamins).

(iii) *Effect of larval food on the longevity, fecundity and sex ratio of Bracon gelechiae Ashm.*—Of the three feeds tried, viz. jowar, jowar + 10% groundnut and jowar + 8% yeast, the last one was found to be the best so far as the longevity, fecundity and sex ratio of the parasite were concerned.

III. *Factors affecting the rate of reproduction of Microbracon brevicornis Wesm.*—From observations made so far it appears that a 10% sucrose feeding, a temperature of 27°C. combined with 70% relative humidity, a host density of four larvae per female and light are some of the factors that favour the rate of reproduction and fecundity of this parasite.

IV. *Studies on chalcid egg parasites of Pyrilla sp.*—

(i) *Longevity of Ageniaspis pyrillae Mani.*—Observations showed that feeding the parasites with glucose, sucrose, and fructose significantly raised the longevity of the males and females as compared to no food under all conditions of temperature and humidity tried. There was, however, no significant difference in longevity within the sugars at 1% level.

(ii) *Effect of different temperatures on the immature stages of Tetrastichus pyrillae Craw.*—Observations showed that there was 100% emergence of adults at 18°C., 25°C. and 30°C. with 80% relative humidity and there was no emergence at 35°C. A study of the effect of low temperature (refrigeration) on the viability of the eggs of *Tetrastichus pyrillae* Craw. showed that the viability was not affected by 5 days exposure to 10° C. under 80% relative humidity. The viability was, however, partially and completely affected by increasing the exposure periods to 7 days and 13 days respectively.

(B) Biological control of insect pests

Mass breeding of parasites.—Number of *Corcyra* moths emerged during the year was 197931. 499·5 cc. of eggs were laid by these moths. 1 cc. of *Corcyra* eggs were given to Delhi University.

26·568 lakh adults of *Trichogramma* emerged during the period under report. Ten cards of *Trichogramma* were given to the Director, Central Sugarcane Research Station, Pusa, Bihar, one to the Entomologist, Agricultural College, Orissa and two to the Entomologist of Madhya Bharat Govt. About 20 thousand adults of *Microbracon gelechiae* Ashm. and *M. brevicornis* Wesm. each were reared in the parasite laboratory. 200 cocoons of *M. gelechiae* Ashm., were sent to the State Entomologist, Orissa.

(C) Apiary

At Delhi there was a set back in breeding of the honey bee, *Apis indica* during June 1955 due to hot weather and dust storms. The position slightly improved during post monsoon period though there were minor troubles from *Camponotus compressus* Fabr. (Black ant) and *Philanthus ramakrishnae* T. (bee-hunter) and

which were duly controlled. Brood rearing and foraging activities of the bee were also at stake during October for incessant rains. This period, otherwise, is known to be favourable for bee activities. The activities of the bees further slowed down. with the approach of winter and were at their lowest ebb during the cold months of December, January and portion of February. The bees, usually less active during this period were duly fed with honey solutions and also protected against the chill. Two weak colonies were the victims of the wax moth, *Galleria mellonella* Linn. The activities of the bees started from the later part of February and the brood rearing remained in full swing during March to about the middle of May.

INSECT ECOLOGY AND TOXICOLOGY

I. *Studies on the development and distribution of insects under different ecological conditions*

(i) *Studies on 'Phadka' (Hieroglyphus nigrorepletus* Bol.).—Experiment on the effect of disturbing the position of the egg pods in the soil showed that there was no emergence of nymphs from the pods buried in inverted position while 12% and 50% emergence was obtained from the pods burried side ways and in normal position respectively. These observations established the beneficial effect of ploughing even after the hot dry season is over so far as the control of this pest is concerned. Some experiments were also carried out on the efficacy of various insecticides in the control of this pest.

(ii) *Studies for the construction of Biometer.—Trichogramma evanescens minutum* Riley was reared at two relative humidities, viz. 35% and 75% and under field conditions of temperature. Data were collected on the life periods of the parasite under these different conditions mainly for testing the Biometer constructed earlier for this parasite. The results indicated that the Biometer requires slight modification.

(iii) *The effect of temperature and humidity on the development and distribution of maize and jowar stem borer, Chilo zonellus Swinh.*—It was observed that the larvae of *Chilo zonellus* which apparently hibernate during winter in the field could pupate when kept at favourable temperatures of 25°, 30° and 35°C. This indicates that all of them do not undergo a true physiological diapause. The lower and the upper limits of development of this species were determined to be near 12°C. and 40° C. respectively and the rate of development was studied at a number of intermediate temperatures. In the light of these observations the distribution of the pest in different parts of India was studied and it was concluded that the climatic factor cannot act as a limiting factor for the multiplication of this pest in any part of India.

II. *Studies on population determination and assessment of damage*

(i) *Bagrada cruciferarum.*—During studies on the bioclimatic fluctuation in the population of this pest it was observed that the population of the pest (adults and nymphs) was low in crop of 'toria' during the months

of January to March. After the crop was harvested about the end of March, large numbers of adults and nymphs were found congregated beneath the bundles of the harvested crop. The pest showed migratory habits and collected at places of adequate shelter and shade. A reduction in the oil content of the damaged seed to the extent of 4·5% was observed. For the first time it was possible to rear *B. cruciferarum* to adult stage on mustard seed. A little of the vitamin 'riboflavin' added to these feeds also increased the longevity of the adults thus reared.

(ii) *Lepotocorisa varicornis*.—The bug appeared for the first time in September. The population was at its peak on early sown paddy during first fortnight of October and then declined gradually. In late sown crop the intensity was high till the 3rd week of October. The insect could be located with difficulty on wild grasses upto middle of November and then it disappeared.

III. *Effect of chemical control on the biological balance in cultivated crops*

(i) *Control schedule for mustard crop*.—The aphid infestation this year was early and severe. During the whole season in all six sprayings were found to be necessary in the case of aldrin, dieldrin and nicotine sulphate (this was later on substituted by basudin); five sprayings were necessary with nicotine sulphate (or basudin) + *gamma* BHC and only four sprayings with *gamma* BHC and Pestox III. The crop was distinctly better in the case of plots treated with pestox and *gamma* BHC while in the untreated control the crop was almost completely destroyed. The average yield of mustard seed per plot (18′×32′) in different treatments was : Pestox 11 lb., gamma BHC 8 lb. 14 oz., Nicotine sulphate (or basudin) + BHC 6 lb. 14 oz., Nicotine sulphate (or basudin) 5 lb. 11 oz.,dieldrin 5 lb. 10 oz., aldrin 2 lb. 12 oz. and control 1 lb. 5 oz.

(ii) *Effect of chemical control on the natural balance of insect population in the cotton crop*.—Cotton crop was sprayed five times with wettable DDT at the rate of 1 lb/acre. After 5th spraying the populations of aphids, jassids, thrips, white flies, and pink bollworms were reduced by 91·1%, 36%, 89·7%, 41·2% and 47·4% respectively and those of spotted bollworms went up by 10%. The population of mite increased to an extent of 7800%. Two months after the 5th spraying the population was found to have been reduced in the treated plots by 100% in jassids, 68·8 % in aphids, 88·3% in white fly, 93·8% in thrips and 64% in pink bollworm. The mite population increased by 5000% ; that of spotted bollworm was not affected.

IV. *Exploration of factors determining the susceptibility of insects to insecticides*

(i) *Studies on insect cuticle in relation to susceptibility to insecticides*.—Studies were carried out on the outermost layers of the epicuticle of six species of insects. The outermost layer in *Tribolium castaneum* H. and *Latheticus oryzae* W. larvae was found to be only a wax layer. In

the pupae of *Trogoderma granarium* Everts, the cement is wanting and even the wax is missing in the inter-segmental regions between the tergites. In the adults of *Trogoderma granarium*, *Laemophloeus minutus*, *Oryzaephilus surinamensis*, *Rhizopertha dominica*. *Latheticus oryzae* and *Tribolium castaneum* the outermost wax layer is not uniform. Cuticular lipid was extracted from the exuviae of *Tribolium castaneum* Hbst. It is a hard material brown in colour and melting at 75·5°C.

(ii) *Effect of the ecological factor, temperature, on the toxicological response : susceptibility of insects to fumigation.*—Experiments conducted under different combinations of temperature components with carbon disulphide and ethylene dichloride against *Tribolium castaneum* showed that there is a very complex interaction between fumigation and postfumigation temperatures on the one hand and the prefumigation temperature coefficient of insect mortality on the other. Further critical experiments are necessary for a final interpretation of the data collected so far.

V. *Bioassay of Insecticides*

(i) *Comparative susceptibility of the different stages of the stored grain pest, Trogoderma granarium Everts.—Trogoderma granarium* has been considered to be one of the most resistant pests. The work conducted during this year has shown that this extraordinary resistance is confined to the larval stage and both the pupal and adult stages are quite susceptible to insecticides. Insecticidal concentration—mortality relationship both for pupal mortality based on counts of the pupae from which the emergence did not take place upto 7 days after treatment and the total mortality based on the number of pupae from which adults emerged but subsequently died upto 7 days after the application of insecticides, has been worked out for DDT, lindane, aldrin, dieldrin and toxaphene. Effect of these insecticides on oviposition of the adults which emerged from the treated pupae showed that films and direct sprays of aldrin, dieldrin, lindane and toxaphene emulsion were quite effective in checking the oviposition of the adults. Besides providing clues for practical control these observations also afford the example of a fundamental phenomenon of the delayed action of the insecticides in stages subsequent to those actually treated.

(ii) *Comparative toxicity of insecticides as contact and stomach poisons*

(*a*) The contact toxicity of the films of different concentrations of aldrin, dieldrin, isodrin, endrin, gamma BHC and DDT was determined using the adults of *Mylloceras maculosus* (Curculionidae), a pest of cotton as test insect ; the tentative order of toxicity of these insecticides was found to be : DDT > endrin > isodrin > dieldrin > aldrin > gamma BHC.

(*b*) The toxicity of Pestox III as a stomach poison to chewing insects was studied using *Myllocerus maculosus* adults, *Athalia proxima* larvae, *Utetheisa pulchella* larvae and II stage locust hoppers as test insects. It was found that 40 mg. of the poison per leaf gave 76·7% mortality in *M. maculosus*, 86·7% in *Athalia proxima*, 86·6% in II stage locust hoppers and 80 mg. per plant gave 77·8% kill in the case of *Utetheisa pulchella* larvae. The insects were allowed to feed on treated leaves for 24 hours.

(*c*) Pestox III and *gamma* BHC were tried as contact sprays against *Coccinella septempunctata*, a predator on aphids. Concentrations upto 0·25% gave no mortality, while those between 0·5% and 1·0% gave 23·3 to 33·3% kill in the case of gamma BHC and 13·3% to 20·0% kill in the case of Pestox III.

(*d*) A sample of glycerine thio-cyanoacetate, received from the Chemistry Division, was tested as contact insecticide against *Tribolium castaneum* and as stomach poison against Vth stage locust hoppers. Concentrations as high as 10% proved ineffective both as contact and as stomach poison.

(iii) *Comparative toxicity of Fumigants.*—Contrary to normal expectations it was observed that when used as fumigants in bins with about 25 seers of broken wheat, carbon tetrachloride was superior to EDCT mixture and also to ethylene dichloride alone. The test insects were adults of *Tribolium castaneum* kept at surface and one and two feet below the surface.

VI. *Toxicological and ecological studies on locust.*—Gamma BHC, endrin and isodrin were injected in the body cavity of the Vth stage locust hoppers by means of a locally improvised micro-syringe and the values of their MLD were found to be approximately 2·6, 1·2 and 3·2 microgram per gram body weight of the insect. Work was also carried out by a unit for locust research for the Directorate of Plant Protection on the standardisation of doses and strengths of aldrin and BHC for effectiveness and economical use against various stages of locust under desert and semi-desert conditions. Experiments conducted with aldrin dusts showed that the hoppers were generally more susceptible to dusts at a higher humidity of 81% then at a lower humidity of 21%. The results were however erratic and conclusions only tentative. Observations on the persistance of the toxicity of aldrin dusts both in the field and laboratory showed that the toxicity of the films was greatly impaired after 3 days exposure in both cases, the results being much more pronounced in the former case. A technique was developed to spray locusts in flight and also to measure the speed of flight. In some preliminary trials 85% to 90% of the adult locusts died in 48-72 hours with 0·25% aldrin emulsion spraying against no mortality in the control, the spraying being done for 45 seconds against locusts made to fly at a speed of 10 miles per hour. With reduction in the period of spraying to 5 seconds and 2 seconds, the mortalities came down to 70% and 20% respectively in 48 hours against no mortality in the control. Studies on the moisture content of

the soil where eggs were being laid by *Schistocerca gregaria* showed that the same ranged between 10·1% to 12·8%. In another experiment soil samples with different moisture contents ranging from 5·5% to 17% were kept inside the locust cage along with sand of 4% moisture content. Egg laying was observed only once in soils of 6·8% and 14·8% moisture contents whereas egg laying took place twice in the same

VII. *Effect of contact insecticides and fumigants on the infestation and viability of stored grains.*—Observations on seeds of cowpeas K. 397 and maize yellow 2 treated with different concentrations of the dusts of DDT and pyrethrum and fumigated with HCN, CS_2 and chlorosol and stored under normal conditions for one season showed that viability was not impaired in any treatment. As in maize the infestation was low in all the treatments including control (maximum of 2·5%) the results were not conclusive about infestation. In cowpeas the infestation went upto 87% in the control but it ranged between only 3% and 13·4% in treated grains. Wheat NP 718 and peas NP 29 were similarly treated with dusts of 10% DDT, 0·5% gamma BHC, 0·5% dieldrin and 0·2% pyrethrins and fumigated with HCN, CS_2 and chlorosol and stored at Delhi and Pusa (Bihar). There was no impairment of viability in any treatment. At Pusa the infestation in control was seen to be as high as 53·5% but there was absolutely no infestation in wheat treated with 10% DDT and 0·2% pyrethrins in combination with 1% piperonyl butoxide. At Delhi the infestation ranged between. 0·4% and 1·4% in treated grain and went upto 13·7% in the untreaed grain.

VIII. *Field and laboratory tests with Pyrethrum against important crop and stored grains pests.*—Laboratory tests were in progress to see the comparative effectiveness of emulsions containing pyrethrins on a number of field pests. Pyrethrins were used singly and also in combination with the two synergists, viz., piperonyl butoxide and *Myristica* extract. Used as emulsion spray, as low a dose as ·0025% of pyrethrins alone was effective against *A. foveicollis* adults causing 63·3% mortality. The same dose of pyrethrins in combination of 1% piperonyl butoxide gave 96·67% mortality against nil in the control. In the case of *Bagrada cruciferarum* there was 57·7% mortality due to spraying of 0·1% pyrethrins alone against 96·7% and 68·8% in the case of pyrethrins in combination with 1% solutions of piperonyl butoxide and *Myristica* extract respectively in 24 hours. There was a mortality of 29·3% in the control under similar conditions. For comparison with lead arsenate used as stomach poison a 0·2% concentrate gave 36·6% mortality in *A. foveicollis* against nil in the control.

IX. *Control of fly breeding in compost pits.*—This year the insecticidal dusts were applied in one set of pits as one layer two inches below the top surface and in another set as two layers— one in the surface and the other 2 inches below the surface. The efficacy of various insecticides, based on the number of flies emerged from each treatment, was found to be in the following order : Endrin>aldrin>gamma BHC> blank>control. However, the degree of control was not quite satisfactory in any of these treatments so far tried. Some further modification of the technique of application is envisaged.

Phenological observations on a number of crop pests were continued.

Scheme for Research on the biology and control of termites affecting agricultural crops

1. *Effectiveness of insecticides in termite control*

Wheat.—In a field experiment during 1955-56 aldrin, dieldrin and chlordane at concentrations of 0·25%, 0·5% and 1·0% were sprayed in the furrows at the time of sowing at 16 gallons/acre. Damage ranged from 2·1% to 5·1% in the treated plots as against 7·3% in the control; dieldrin at 1% strength showed least damage.

2. *Residual effect of the different insecticides on the control of termites*

Wheat.—The residual effect of the various insecticides used during 1954-55 was assessed in terms of percentage damage of the crop, tillers per plant and yield of grain. So far as damage to the crop was concerned, Tech. dieldrin at all rates (5, 10 and 15 lb/acre) and DDT+BHC and DDT+toxaphene at only higher rates (15 lb/acre) gave better results as compared to control. There was however very little difference in tillering or yield of grain between the treated and untreated plots. Observations on the effect of seed rate on termite incidence was also under progress.

SCHEMES UNDER THE SECOND FIVE YEAR PLAN

(i) *Entomological investigations with the help of radioactive Isotopes*

The following preliminary studies on the effect of radioactivity on the rate of reproduction, development, and longevity of *Microbracon gelechiae* (Ashmead) were carried out.

I. The parasites fed with 50 μc and 100 μc per gm. of 10% Glucose solution per parasite made them radioactive so as to give 70 c.p.m. and 100 c.p.m. respectively.

II. *Irradiation.*—Parasites feeding on normal 10% Glucose solution were irradiated with radioactive p32 and it was observed that a dose of 250 μc produced little activity in the parasites, while a doze of 500μc produced slight activity after 24 hours of irradiation.

III. Full grown caterpillars of *Corcyra cephalonica* (Stainton) a laboratory host of *Microbracon gelechiae* (Ashmead) were made radioactive and these radioactive caterpillars were allowed to be parasitized by normal females of *Microbracon gelechiae* and preliminary observations showed that :—

(*a*) Radioactivity is passed on to the parasite even upto the next generation

(*b*) The fecundity of the parasite and viability of the eggs (at higher levels of radioactivity) are adversely affected.

(ii) *Biological Testing and Certification of Insecticides*

Dusts.—Two commercial formulations of BHC dust namely Hexidol 810 (10% BHC, Geigy product) and Lethalrock 5% BHC (Flintrock product) were compared for their toxicity with a standard laboratory formulation. *Tribolium castaneum* adults were used as test insects.

Wettable powders.—Two samples of DDT wettable powder (50%) sent by the Entomologist, Punjab were tested and compared for their toxicity with a standard sample of DDT wettable powder. The results were communicated to the Entomologist, Punjab.

Emulsions.—Commercial emulsifiable concentrates of DDT (Flintrock product), aldrin (Burmah Shell product) BHC, (I.C.I. product) were compared for their toxicity with the laboratory prepared emulsions formulated from the respective technical grades of the insecticides. Also samples of Duolit emulsions of DDT and Contal 53 (*gamma* BHC) received from Germany and an insecticide sample sent by the Director of Storage, Ministry of Food & Agriculture were bioassayed.

(iii) *Studies on the ecology of the pests of stored grain*

Preliminary ecological surveys of the storage problems were carried out at Jaipur, Karnal, Pusa (Bihar), Bombay, Madras and Delhi. Data were collected on the effect of different types of storage of various kinds of grains on the infestation and viability of these grains. Information was also collected on the chemical control methods adopted at some of these places against the stored grain pests. The development of the various stages of *Trogoderma granarium* were carried out at three temperatures (10°, 25° and 30°C.) and two relative humidities (75% and 90%).

(iv) *Survey of beneficial parasites and predators of Agricultural crops in the Indian Union*

An intensive survey of the standing crops at the I.A.R.I. carried out during the period under report yielded an unidentified species of *Apanteles* and an Ichneumonid endoparasite, *Angitia argentipilosa* (Cann.) reared from *Polyommatus boeticus*. Another *Apanteles* sp. was reared from *Porthesia xanthorrhoea*, a pest of pigeon pea. The *Apanteles* sp. on this pest has been successfully bred in the laboratory too on the same host. Studies on the parasite revealed that the parasite is a gregarious endoparasite and prefers the earlier host instars.

The biology and morphology of *Solenotus* sp., *Rhopalotus* sp. and an unidentified braconid, all three parasitising *Phytomyza atricornis* (Meign.), the pea leaf miner were studied in considerable detail.

During the period under report the cotton crop at Indore and wheat, juar, citrus, cotton and vegetable crops in Madhaya Pradesh were surveyed, and parasites and predators of the pests in these crops were collected. At Delhi a few parasites were also reared from pests of sugarcane and lucerne.

(v) *Seed Testing*

Six hundred and fifty three samples of seeds were examined, treated and the health certificates were issued, wherever necessary. The seeds received were of cereals, vegetables, grasses, lentils, peas, flowers, oil seed crops, tubers and some cactus plants and herbarium specimens. Out of these, 453 samples were imported and the remaining were meant for export to other countries. About 250 herbarium specimens and seed samples from Agrastology Section, Agronomy Division, were examined and suitably treated.

(vi) *Insect physiology*

1. *Morphology and physiology of the insect egg shell and the penetration of chemicals through it.*

(a) *Studies on the eggs of Hymenoptera.*—The chorion of the egg of *Microbracon gelechiae* Ashm. consists of proteinaceous and non resistant exochorion and resistant endochorion. Exochorion is covered externally by non resistant proteinaceous secretion of necessary glands. The chorion has innumberable respiratory

pores. The poison gland secretion is proteinaceous and contains only a little lipoid. The globular cells around the poison duct secrete lipoid material which lubricates the inner passage of ovipositor, but does not soften the chorion The secretion from the lubricating gland is also proteinaceous but contains rich complement of lipoid. The eggs of *Trichogramma evanescens minutum* Riley have no lipoid layer on the inner surface of chorion but a little lipoid is mixed with serosa. The serosa is comparatively more resistant to the action of corrosive materials than the chorion.

(*b*) *Studies on the eggs of Diptera.*—Eggs of *Musca* sp., *Sphaerophoria* sp. and *Dacus* sp. also could hatch out successfully in water. The chorion appears to have some lipoid on the outer surface whereas the inner surface has complete layer of lipoid to resist the entry of aqueous solutions. The lipoid soluble materials penetrate through the egg shell easily. The cement and the chorion do not resist the penetration of aqueous soluble materials. The egg-shell of *Musca* sp. and *Dacus* sp. consists of outer soft cement, external soft chorion and inner resistant chorion. The vitelline membrane is neither very soft nor very resistant.

2. *Investigations on the Neurosecretion in insects.*—The neurosecretory cells in the advanced third instar maggot of *Sphaerophoria* sp. and *Musca* sp. are clustered together in the mid region of Pars-intercerebralis and the secretion from them diffuses to the entire cerebral lobes. In the brain of adult *Musca* sp. the neurosecretory cells are smaller and the secretion is comparatively less and distributed only on the periphery.

3 *Sensory physiology and physiological behaviour of Dacus sp.*—An olfactometer and hygropreferandum apparatus have been constructed. The maggot show preference for the wet side and hygroreceptors appear to be located on the anterior part of head.

PROGRAMME OF WORK FOR 1956-1957

RESEARCH PROBLEMS

A. Section of Parasitology

1. Effect of nutrition on the fecundity, longevity and sex ratio of *Bracon gelechiae* Ashmead and *Trichogramma evanescens minutum* Riley reared on *Corcyra cephalonica* St. fed on various synthetic diets.

2. Host selection and distribution of progeny in *Microbracon chinensis* Szep. and *M. brevicornis* Wesm.

3. Studies on coefficient of parasite efficiency of some parasites of cotton bollworm and the root, stem and top borers of sugarcane.

4. Biological control of pink bollworm (*Pectinophora gossypiella* (Saunders) by means of its parasites *Apanteles angaleti* Muesebeck and *Microbracon brevicornis* Wesm.

5. Biological control of the potato tuber moth infesting potato in storage in Patna district.

6. Studies on Chalcid egg parasites of *Pyrilla perpusilla* Walk.

7. *Scheme under the Second Five Year Plan*–

   (i) Survey of beneficial parasites and predators of pests of crops in the Indian Union.

   (ii) Effect of selective breeding on the longevity fecundity and sex-ratio of *Trichogramma evanescens minutum* Riley.

B. Section of Insect Ecology and Toxicology

1. Studies on the development and distribution of insects under different ecological conditions.

2. Studies on population determination and assessment of damage.

3. Effect of chemical control on the biological balance of cultivated crops.

4. Factors responsible for variation in the susceptibility of insects and the toxicity of insecticides.

5. Bioassay of insecticides.

6. Toxicological and ecological studies on the Desert Locust.

7. Studies on the effect of the contact insecticides (DDT, BHC, Dieldrin) and fumigants (CS_2, HCN and Chlorosol) on the insect infestation in stored grains and the viability of seeds.

8. Field and laboratory tests with pyrethrins against important crop and stored grain pests.

9. Laboratory tests on the chemical control of the Desert Locust in flight and in situ.

10. Oviposition response by the Desert Locust.

11. Phenological observations on crop pests.

12. On the control of fly breeding in compost.

13. Use of repellents against hoppers and adults of the Desert Locust.

14. I. C. A. R. Termite Research Scheme.

15. *Schemes under the Second Five Year Plan—*

(i) Entomological investigations with radioactive Isotopes.
(ii) Biological testing and certification of insecticides.
(iii) Ecological studies on the insect pests of stored grain.
(iv) Testing and certification of improved varieties of seeds.

C. Section of Systematic entomology

1. Taxonomy of Indian Curculionidae (Coleoptera).
2. Taxonomy of Indian Vespidae (Hymenoptera).
3. Taxonomy of Indian Aeshnidae (Odonata).
4. Studies on Indian Ichnuemonidae (Hymenoptera).
5. Revision of the Chalcididae (Hymenoptera).
6. Taxonomy of Indian Tenebrionidae (Coleoptera).

D. Section of Insect Physiology

1. Breeding for resistance to insect pests.
2. Studies on the eggs of a few beneficial parasites and injurious insect pests.
3. Investigations on the Neurosecretion in Insects.
4. Investigations on the digestive physiology of insects.

REPORT OF THE DIVISION OF MYCOLOGY AND PLANT PATHOLOGY

(DR. R. S. VASUDEVA)

RESEARCH

A. SECTION OF PLANT PATHOLOGY

1. *Wheat* (*Triticum aestivum* L.)

(*a*) *Rusts* (*Puccinia graminis tritici* (Pers.) Erikss. and Henn., *P. triticina* Erikss., and *P. glumarum* (Schmidt) Erikss. and Henn.).—Three hundred and forty-six rust samples, collected from different parts of the country, were analysed for physiologic race study and races 21, 24, 34, 40, 42, 42-B and 75 of black rust, races 10, 11, 20, 26, 63, 77, 106, 107 and 108 of brown rust and races 13, 19, 20, A and E of yellow rust were obtained. Two new races of brown rust (one resembling race 70) and one of black rust (resembling race 17) were observed. Race 77 of brown rust, reported last year from 1953-54 crop for the first time, was found in the collections from Punjab, Uttar Pradesh Madhya Pradesh, Bombay and Madras on the improved wheat varieties N.P. 111, N.P. 745, N.P. 760 and N.P. 770. Races 21 and 42 of black rust, races 10, 20 and 63 of brown rust and races 19 and A of yellow rust were predominant and widely distributed throughout the country, whereas the virulent race 122 of black rust, observed during the last two years, was not encountered at all. A new virulent biotype of race 21 of black rust, designated as 21-A, was, however, picked up during the period under report. It differs from the parent race in its virulence on wheat varieties E. 535, E. 541 and E. 666.

Extensive survey of Himachal Pradesh as also of Kulu and Lahaul valleys showed that the rusts could survive during summer months in various localities. *Muehlenbergia hugelii*, a perennial grass growing wild in the upper Simla hills, was found to be naturally infected with yellow rust, thus confirming its role as a collateral host. This grass was also found to harbour another rust, belonging to the genus *Puccinia*, which is under study. Besides the survey for naturally infected grasses, testing of grasses in the glasshouse was also done. Twenty-four species of grasses, belonging to 17 genera, were tested with black rust of oats and 14 species with black rust of wheat, but none of them was found to be susceptible to either of the two rusts. A large number of species of *Agropyron* and *Aegilops* were, however, found to be susceptible to all the three rusts of wheat when artificially inoculated.

Study of alternate hosts showed that the aecidial stage on *Berberis* sp., collected from Lahaul valley, was not connected with black rust of wheat. *Berberis jaeschkeana*, collected from the same area, was found to be resistant to black rust of wheat under glasshouse conditions as judged by its reaction to races 21 and 42. Selfing studies with races 21 and 42 of black rust of wheat have shown that the two races are heterozygous.

In aerobiological studies, aeroscope slides from 22 rust nurseries exposed during 1954-55 and 5 during 1955-56 were examined. From the first lot, 5 cases of spore showers for the outbreak of black rust and 2 for brown rust took place at least 7 days before the recorded date of rust appearance at the respective localities. In the latter case, spore showers of significance were encountered at 2 nurseries for all the three rusts and at 1 nursery for black rust only.

In all 17,909 plants of wheat varieties, crosses and hybrids were tested against individual races of the three rusts or their mixture in the seedling stage. Wheat variety E. 4613 was found resistant to all the races of black and brown rusts and E. 1844 to all the races of yellow rust except race 19. Out of 61 wheat varieties and selections tested with race 122 of black rust, E. 336, E. 750, E. 855, E. 930, E. 931. E. 941, E. 984, E. 1860. E. 1906, E. 1914 and E. 2564 were found resistant. In similar tests with 22 wheat varieties against race 77 of brown rust, varieties W. 160, E. 576, E. 578, E. 617. E. 628, E. 1834, E. 1847, E. 1912, E. 1915, E. 2143, E. 2144, E. 2285, E. 2543 and E. 2546 were found resistant. In addition, 18 wheat cultures, out of 97 under test in the seedling stage, were found to be resistant to a mixture of yellow rust races. Wheat variety N.P. 785 proved to be resistant to all the races of yellow rust individually.

In the adult resistance tests, about 1.25,000 plants were examined in the field for their resistance to the three rusts of wheat after creating artificial epidemic. Necessary help was given to the Plant Breeder in the selection of promising material.

Work on the survival of black rust races in mixture was initiated. The method of mixing equal spore load of the two races in a combination was first standardized by taking uredo-material of the two races from equal number of pustules, presumably each produced by a single spore. Actual competition in the two races was studied on a highly susceptible variety of wheat, while the percentage of races in each generation was calculated on a set of differential hosts which distinctly showed two types of reactions with the two races under study. The chief combinations thus studied were 21+40, 21+42 and 122+194. The first combination, maintained for 6 successive generations, did not show any appreciable change in the frequency of the two components. It was further observed that in all the cases, where race 72 was one of the components of the two races used, it (race 72) always got suppressed even in the very first generation.

Due to low natural incidence of rust infection this year, it was not possible to evaluate the effect of different fungicides (finely powdered sulphur, ultra sulphur and Dithane) tried for the chemical control of rusts at Delhi. Yields obtained from the plots dusted weekly with finely powdered sulphur and ultra sulphur, however, showed appreciable increase in yield. The results are similar to those obtained last year.

(*b*) *Loose smut* (*Ustilago tritici* (Pers.) Rostr.).—Out of 96 wheat varieties tested for their resistance to the disease at Delhi and Simla, 72 remained free from infection and may be considered as promising from the point of view of loose smut resistance. N.P. 721, E. 220, E. 957 and W. 206/pl. 40 have been found resistant to the disease during the last three tests. N.P. 784, N.P. 789, N. P. 790, N.P. 791, N.P. 792, N.P. 795, N.P. 796, N.P. 797, N.P. 798, N.P. 799, N.P. 800, N.P. 801,

N.P. 802, N.P. 807, N.P. 809, N.P. 810, N. P. 813, N.P. 814, N.P. 815, E. 671, E. 1913, E. 1914, E. 2143, E. 2158, HD-(52)-46, HD-(52)-67, HD-(52)-70 HD-(52)-71 and S. 40, which were smut free in the last year's test, did not show infection again this year.

For selecting resistant strains within the highly susceptible wheat variety N.P. 775, 227 smut-free selections of this wheat, made during the year 1954-55 from the crop raised from artificially infected seed were inoculated with the pathogen. One hundred and three selections (smut-free and with desirable agronomic characters) were also made from the plot sown with the last year's mass inoculated material of N.P. 775. These selections will be retested during the next season. Crosses of N.P. 775 with the resistant varieties N.P. 790 and N.P. 718 in different generations were inoculated with the pathogen for selecting resistant hybrids.

Some indication of physiologic specialization within the pathogen was obtained in preliminary tests. Loose smut infected seed of Punjab C. 591, soaked in 0·1 per cent Spergon at 30°C. for 11, 17, 23 and 29 hours, showed 8, 6, 2 and 6 per cent disease incidence, respectively, as against 9 per cent in the untreated control. These results, however, require to be confirmed.

(*c*) *Flag smut* (*Urocystis tritici* Koern.).—An experiment was laid out this year to test the resistance of some important wheat varieties against the disease. A disease-sick plot was created by adding plenty of inoculum to the soil and ten varieties were planted. As the experiment was started late, disease incidence in general was low. Preliminary observations, however, indicated that wheat varieties N.P. 755, K.13, C. 518 and C.591 were susceptible, while N.P. 4, N.P. 718, N.P. 761, N.P. 790, N.P. 809 and *Agra local* remained free from infection. These results require to be confirmed.

(*d*) *Karnal Bunt* (*Neovossia indica* (Mitra) Mundkur) and *Hill Bunt* (*Tilletia caries* (DC.) Tul. and *T. foetida* (Wallr.) Liro).—In the varietal resistance tests against Karnal bunt at Karnal, 99 wheat varieties were inoculated with the sporidial culture of the fungus by the Hypodermic Syringe method in boot-leaf stage and by Moore's Partial Vacuum method at mid-anthesis stage. Due to unfavourable weather conditions, the infection percentage was low. However, the results showed that at least 17 varieties were susceptible. It was further observed that chlamydospores of Karnal Bunt pretreated with lactic, citric and oxalic acids at 0·5-1·0 per cent concentration for 5-10 minutes gave better germination than the untreated spores.

One hundred and forty-seven wheat varieties were further tested against *Tilletia foetida* (Hill bunt) at Simla for their resistance to the disease. Four wheat varieties (E. 56, E. 201, E. 740 and E. 2327) were found to be highly resistant, 3 (E. 187, E. 872 and W.B. 64) were moderately resistant as these showed about 30 per cent infection and the remaining 140 varieties, showing 40-90 per cent infection, were considered as highly susceptible. Preliminary studies have shown that there are at least two physiologic races each of *Tilletia foetida* and *T. caries* in this country.

2. *Barley* (*Hordeum vulgare* L.)

(*a*) *Rust* (*Puccinia graminis tritici* (Pers.) Erikss. and Henn., *P. glumarum* (Schmidt) Erikss. and Henn. and *P. simplex* (Koern.) Erikss. and Henn.).—Fourteen samples of black and yellow rusts, collected from different parts of the country, were analysed and races 21, 34, 40 and 42 of black rust and races 19 and G of yellow rust were obtained. Nine barley varieties were tested against individual races of yellow rust in the seedling stage and varieties B. 240 and B. 241 were found resistant to all the races except race G. Out of these, 6 varieties were also tested with individual races of black rust, but none was found resistant. In addition, 5 barley varieties were tested with mixtures of races of black and yellow rusts separately, but no variety proved to be resistant.

In the adult resistance tests at Delhi and Simla, the following barley varieties or crosses were found to be completely free from black and yellow rust infection: B. 51, B. 53, B. 63, B. 64, B. 216, B. 250, B. 254 to B. 256, B. 267, B. 272, E. 255, E.C. 7792 to E.C. 7795, N.P. Hyb. 2, P.C. 8, C. 155-4, C. 155-21, Code 1 Pl. 14, Plumage, Szdigamiski, Afg. 13, Ch. Archer x N.P. 21 (6-53-19), Auskarpuntta, Kutnowiski, U.N. 136-1, Alpha, Kujanniski, Australian (263. B), Cape, Alpha x N.P. 21 (4-409-66), Plumage No. 2, Sparthacher, Striped 12-6 P, Barzynawiski and Gran 26-2 P.

Evidence was obtained that there are at least two physiologic races of leaf rust of barley (*Puccina simplex*) in this country.

(*b*) *Loose smut* (*Ustilago nuda* (Jens.) Rostr.).—In the varietal resistance tests with 28 barley varieties, B. 47, B. 237 and B. 240 proved resistant. Cross-inoculation tests with *Ustilago tritici* and *U. nuda* showed that they are host-specific, although morphologically they are alike.

3. *Maize* (*Zea mays* L.)

(*a*) *Rust* (*Puccinia sorghi* Schw.).—Fourteen rust samples, collected from Punjab, Jammu and Kashmir, and Nilgiris, were tested on 10 inbred lines of maize for physiologic race study, but no evidence of physiologic specialization within the pathogen has so far been obtained. Further work in this connection is, however, in progress.

(*b*) *Downy mildew* (*Sclerospora philippinensis* Weston).—It was experimentally shown that the disease was not seed-borne. The pathogen was found to occur on 'Kans' grass (*Saccharum spontaneum*), indicating the possibility of its serving as a collateral host for the downy mildew of maize, which would explain the annual recurrence of the mildew despite the absence of the oospore stage of the fungus. This, however, requires further confirmation as the fungus observed on 'Kans', although morphologically similar to *Sclerospora philippinensis*, has so far given negative results in the inoculation tests on maize. The infected clumps of 'Kans', kept under observation from August, 1955, to July, 1956, gave rise to new shoots which were heavily infected, indicating thereby that the fungus was systemically carried within the tissues of the host and that, during unfavourable conditions, it perennated inside the underground parts (rhizome and basal parts of shoot).

4. *Bajra* (*Pennisetum typhoides* Stapf and Hubbard)

Green-ear disease (*Sclerospora graminicola* (Sacc.) Schroet.).—Oospore material of *Sclerospora graminicola* after weathering during winter alone did not germinate, whereas that exposed to both summer and winter germinated satisfactorily. Seed treatment with three fungicides, namely, Arasan, Ceresan and Spergon, as anticipated, failed to control the disease.

5. *Sugarcane* (*Saccharum officinarum* L.)

(*a*) *Red Rot* (*Colletotrichum falcatum* Went).—During the year under report, red rot was reported in the form of localised epidemics from certain areas of Jagadhari (Punjab) and Pilibhit (U.P.) and the cane varieties Co. 312, Co. 453 and Co.J. 32 were found to be affected. Isolations from the diseased canes, collected from these areas, yielded light type cultures of *C. falcatum*.

In the Physiologic-Forms studies, twenty-eight isolates of *C. falcatum*, including those received from Shahjahanpur (affecting Co. 213), were tested on the ten standard cane varieties (Co. 213, 223, 299, 312, 313, 331, 356, 419, 421 and 445), having different genetic composition and possessing varying degree of resistance to red rot, but no physiologic specificity within the pathogen was observed. A good deal of variation in virulence of these isolates was, however, observed. The light type isolates, as usual, were found to be more virulent than the dark ones.

In the varietal resistance tests, 182 cane varieties were tested by the Plug method with *C. falcatum* isolate No. 244. None of the varieties was found to be resistant, 74 behaved as moderately resistant and the remaining 108 as susceptible. In similar tests with 96 cane varieties by the 'Nodal Infection' method, one variety (S.G. 227/9) was found to be resistant, 5 (Co. 312, 766, 966, 1029 and 1041) as moderately resistant and the remaining 90 were susceptible.

In order to study the effect of mixed inocula on red rot infection, different combinations of dark and light type, light and light type, and dark and dark type isolates of *C. falcatum* were tried on the ten standard cane varieties. All the varieties, except Co. 331, gave more infection when inoculated with a mixture of light and dark type isolates (Nos. 244 and 334) than with the individual ones. Similarly, in the case of isolate Nos. 359 (light) and 334 (dark), the mixed inoculum proved more virulent than that of individual isolates in 9 varieties out of the ten used. It was further observed that 6 varieties gave more infection with the mixture of light and dark type isolates as compared to the infection obtained with the mixture of two light type isolates. There was no significant increase in infection when the dose of inoculum was doubled.

In the experiment to study the relative resistance and susceptibility of the plant and ratoon crops to red rot, 5 varieties, out of the 10 tested, gave more infection in the case of the first year ratoon crop, 2 in the second year ratoon crop and 3 in the plant crop. In general the ratoon crop was, however, comparatively more susceptible than the plant crop.

(*b*) *Smut* (*Ustilago scitaminea* Syd.).—In the varietal resistance tests, 109 cane varieties at Delhi and 90 at Karnal were inoculated with smut spore suspension and then planted in the field for observations. At Delhi, 14 varieties showed less than 5 per cent infection, 7 showed 5-15 per cent infection, 20 gave 15-30 per cent infection and the remaining 68 varieties showed 30-100 per cent infection. The corresponding figures for the Karnal experiment were 28, 12, 11 and 39. Forty varieties, namely, S.G. 227/9, B.O. 9 and Co. 356, 419, 421, 766, 811, 819, 821, 823, 833, 834, 868, 870, 871, 878, 888, 905, 914, 928, 932, 960, 964, 978, 989, 991, 993, 994, 995, 999, 1000, 1005, 1006, 1007, 1009, 1022, 1023, 1025, 1026 and 1027, which showed less than 5 per cent infection, may be considered as resistant. Of these, eight varieties (Co. 356, 419, 819, 821, 868, 871, 888 and 960) had reacted as resistant in the previous tests also.

(*c*) *Rust* (*Puccinia kuehnii* (Krueg.) Butler): The rust, which was so far restricted to South India on Co. 421, 467, 475, 603, 658, 732, 876, 928 and P.O.J. 2878, appeared in an epidemic form in Gola Gokaran Nath area (U.P.) on the chief commercial cane variety Co.S. 510. In later surveys, however, mild infection on Co. 313, 321 and 443 was also observed. The rust culture has been successfully maintained at Delhi since April, 1956, under improvised conditions (Temp. 21-26°C. and 50-60 per cent humidity) on Co. S. 510 and Co. 603. It cannot survive the summer heat of Delhi, as spores do not germinate above 30° C.

6. *Linseed* (*Linum usitatissimum* L.)

Rust (*Melampsora lini* (Pers.) Lev.).—In all, 108 rust samples (92 from 1954-55 crop and 16 from 1955-56 crop) were analysed and all the five Indian races of *Melampsora lini* were obtained. *Linum trigynum* was found to be immune to all the five Indian races of the rust. Out of 100 N.P. hybrids tested in the seedling stage with individual races, N.P. Hyb. 10 was found to be resistant. In the adult resistance tests with 160 linseed varieties, 119 proved resistant. These were as follows: N.P. Hyb. 10; N.P. R.R. 45; 439 and 440; S. 5; S. 6; S. 24; S. 25; S. 37 to S. 39; S. 50; S. 69; S. 74; S. 75; S. 81 to 84; S. 88 to 92; S. 94 to 148; S. 150 to 183; Holandia 6157; Solider 6163; Fivel 6162; Wierd 6156; Diana 6159; and Noltlerse 6160.

7. *Sannhemp* (*Crotalaria juncea* L.)

Rust (*Uromyces decoratus* Syd.)—It is so far known to occur in the uredial and telial stages only. Teleutospores germinated readily in tap water within 48 hours when kept at 15-25° C., but germinating teleutospores did not infect sannhemp seedlings, indicating thereby that the rust is probably heteroecious. A search for the alternate host has, however, so far given negative results.

Over-summering studies of the rust showed that it could not survive during the summer months at Delhi either as uredospores or as dormant mycelium. Even the teleutospores did not remain viable after more than four weeks of weathering, indicating thereby that the mode of its perpetuation in the plains needs further investigation.

8. *Safflower (Carthamus tinctorius* L.)

Rust (*Puccinia carthami* (Hutz.) Corda).—It appears that the rust is heterothallic as abortive compound pycnia and single pycna were abundantly formed on the inoculated leaves. Occurrence of uredinoid aecidia was demonstrated in microtome sections, showing thereby that the rust is not Brachy-form as, at present, considered. It was further confirmed that teleutospores carried with seed or surviving from the previous season on crop debris and wild species perpetuated the rust. No evidence of root infection or sporulation within the host tissue was observed.

9. *Pigeon pea (Cajanus cajan* (L.) Mill sp.)

Wilt (*Fusarium udum* Butler).—Out of 20 pigeonpea varieties tested for their resistance to the disease, C. 15 (W.E.), T 3 and T 48 did not develop wilt either in the pot or the field test. N.P. 41, which had been found to be consistently resistant to the disease for the last 12 years, proved susceptible during the current year's test.

10. *Antibiosis*

A procedure for isolating the *Bacillus subtilis* antibiotic in which solvent extraction with n-butyl alcohol was followed by ion-exchange chromatography on Amberlite IRC-50 columns was worked out. Evidence was obtained that the antibiotic was produced by *B. subtilis* in soil supplemented with roots of *arhar* or pea or *Melilotus indica* and small quantities of glucose. It was found to remain stable in soil for about a month. More antibiotic was produced in sterilized soil than in unsterilized soil. In preliminary tests, reduced incidence of pigeon-pea wilt (*Fusarium udum*) was observed in the soils amended as above and inoculated with *B. subtilis*. Screening of actinomycetes from soil to determine their antibiotic activity against plant pathogens was continued.

11. *Physiology of Fungi*

Studies on the mechanism of sporulation in *Lophotrichus ampulus* Benj. were continued. Further evidence was obtained to support the role of glucose-1-phosphate in the sporulation of this fungus. Results so far obtained have shown no invertase activity in the mycelium grown in the presence of sucrose at the optimum pH of 4·8. No inhibition of sporulation was observed on sucrose media in the presence of arsenate, benzimidazole and thiouracil. *Phytophthora himalayensis*, which consistently produced oospores in culture on oat meal agar, showed negligible sporulation on a mineral salts-glucose medium supplemented with casein hydrolyzate as a complex source of amino acids and B-vitamins. This medium was, therefore, selected to study the factors responsible for oospore formation in *Phytophthora* spp.

Germination and growth behaviour of uredospores of *Puccinia graminis tritici* was studied with purine and pyrimidine analogues. It was observed that benzimidazole inhibited germination completely and that such inhibition was partially reversible with adenine, indicating thereby that adenine is possibly one of the essential growth factors for the fungus.

Physiology of parasitism of some less specialized fungi like *Fusarium fructigenum* and *F. solani* as also factors affecting virulence of dark and light type isolates of *Colletotrichum falcatum* were under study. It was observed that *F. solani* parasitised both potato and apple, while *F. fructigenum* attacked only apple. Spore germination tests showed that failure of *F. fructigenum* to parasitise potato was not due to any deleterious action of potato juice. A small dose of Brown's synthetic medium given along with the inoculum enhanced the parasitic activity of both the fungi. The exo- and endo- enzymes of the two fungi were found to be of proteinaceous nature.

Studies on plant tissue culture were continued. In White's medium, containing 0·1 p.p.m. of naphthalene acetic acid, apical meristems of safflower produced mostly undifferentiated callus tissue, while linseed stem tips developed into small plantlets with extensive root system.

Screening of soil fungi was in progress with the object of isolating nitrifying organisms. So far, eight fungi have been observed to form either nitrite or nitrate or both in a medium containing peptone and nitrite, respectively.

12. *Effect of atomic radiations on fungi*

Technique of treating fungi with radioactive phosphorus was standardized. Spores of *Colletotrichum falcatum*, *Puccina graminis tritici*, *Phycomyces blakesleeanus*, *Ustilago tritici* and *Lophotrichus ampulus* were treated with low amounts of P_{32} upto 20 microcuries per ml. for varying periods. Subsequent culture studies showed no discernible changes in any of these organisms, except in *L. ampulus* which appeared to have produced two non-sporulating strains.

Soil treated with radioactive phosphorus for periods ranging from one to three months was examined for changes in the quantitative and qualitative flora of fungi and actinomycetes. In the initial activity range of about 90 to 400 microcuries per 10 gm. of soil, an increase in the number of fungi and actinomycetes was noted at the lower levels upto 180 microcuries. The number dropped at higher levels, but was still higher than in the untreated controls. No qualitative changes were, however, apparent at any level.

Wheat seedlings, treated with radioactive phosphorus as superphosphate at a level of about 9 microcuries per pot containing 240 gm. of soil, did not show any differences in their susceptibility to race 15-C of *Puccinia graminis tritici*.

13. *Fungicides*

Replicated field experiments were continued to determine the relative efficacy of 8 commercial fungicides, namely, Agrosan GN (tolylmercury acetate), Ceresan (N-(Ethylmercuri)-p-toluenesulfonanilide), Spergon (tetrachloro-p-benzoquinone),

Lunasan (1-(ethylmercury)-2-thiourea), Aagrano (3-ethoxypropyl mercury bromide), Arasan (bis(dimethyl thiocarbamoyl) disulphide), Sulphur and copper carbonate, on the emergence, stand and yield of maize, *bajra*, wheat and barley crops. Majority of the seed dressings tried showed beneficial effect. Slight increase in the germination of all the crops was observed, except in the case of barley with Agrosan GN. Ceresan in the case of maize and *bajra*, Agrosan GN in the case of wheat and Spergon in the case of barley were, however, the most effective fungicides as judged by the increase in grain yield.

The reported efficacy of "Aretan" (2–Methoxyethyl mercury chloride) and Gama BHC Aretan was tested. The cane setts were treated with two concentrations of the former fungicide (1 lb. in 10 gallons and 1 lb. in 20 gallons of water) and one concentration (1 lb. in 10 gallons of water) of the latter at the time of planting. About 38 per cent increase in yield of millable canes over the controls was obtained in the treatments where the setts were either steeped for 10 minutes in the lower concentrations of the "Aretan" or given an instantaneous dip with higher concentrations. With Gama BHC Aretan, about 29 per cent increase in yield was recorded when the setts were steeped in the lower concentrations of the fungicide.

Laboratory testing of proprietary fungicides as well as new compounds obtained from different sources was taken in hand. Fourteen proprietary fungicides and seven new compounds were tested for their fungicidal properties with *Alternaria tenuis* as the test organism. Three proprietary fungicides (Perenox, Copper Sandoz and Cupra Mar) and one new compound (Camphene chloromercury chloride) were found to be comparatively more effective.

14. *Seed Testing*

Seventy-eight seed samples of wheat, maize, *bajra*, *jowar*, oats, gram and *urid*, collected from Delhi godowns, were examined for ecto- and endo- phytic fungal flora. Nine wheat samples showed internal infection of *Helminthosporium*, while the rest appeared to carry externally species of *Helminthosporium*, *Alternaria*, *Aspergillus*, *Fusarium*, *Penicillium*, *Rhizopus*, *Mucor* and *Curvularia*.

15. *Bacterial diseases of plants*

(*a*) "*Tundu*" (*Yellow ear-rot*) *disease of wheat* (*Corynebacterium tritici* (Hutchinson) Bergey *et al.*).—Earlier work had shown that there was some complex relationship between the pathogen, *C. tritici*, and the wheat nematode, *Anguina tritici*, as the disease could not be reproduced in the absence of nematode galls. Experiments were, therefore, conducted to demonstrate the presence of the bacterium in the growing points of the infected wheat seedlings and in nematode galls. It was not possible to isolate the pathogen from nematode galls or show its presence in them by histological technique. Its presence in the growing points of the infected seedlings was, however, demonstrated by cutting sections of the fixed material.

Attempts were also made to cultivate the wheat nematode (*Anguina tritici*) on an artificial medium. Acidified wheat meal agar and maize meal agar, previously inoculated with *Alternaria tenuis*, were used for the study. Nematode galls were

surface-sterilized and larvae from inside the galls were aseptically transferred to the media. The larvae remained viable under these conditions for about a month.

(*b*) *Brown rot of potatoes* (*Pseudomonas solanacearum* E. F. Smith and *Ps. solanacearum* var. *asiatica* (F. F. Smith) Stapp).—Effect of environmental factors on infection by the brown rot organisms was studied. The disease is favoured by relatively high temperatures and high soil moisture. The infection developed rapidly with increase in soil temperature from 70° to 100°F. and with increase in soil moisture from 50 to 100 per cent water holding capacity. It was further obvious that the pathogen grew, at least *in vitro*, over a wide range of H-ion concentration (5·2 to 9·4). Furthermore, there was decrease in disease severity with increase in age (1 to 2½ months) of the host plant.

(*c*) *Leaf spot of pomegranate* (*Xanthomonas punicae* sp. nov.).—Histo-pathological studies showed bacterial invasion of the parenchymatous tissue, resulting in necrosis of the cells. Presence of one or more B-vitamins in the basal medium was found to be essential for the luxuriant growth of the pathogen. Growth of the pomegranate bacterium was checked by 5 : 5 : 50 Bordeaux Mixture (upto 1 : 10 dilution), 1 per cent Perenox and 4 : 8 : 80 Lime sulphur (upto 1 : 50 dilution), thus indicating that spraying with these fungicides may control the disease under field conditions. Since the pathogen survives in the dried fallen leaves during the off-season (December to March), it may also be helpful if the diseased leaves are collected and burnt.

(*d*) *Citrus canker* (*Xanthomonas citri* (Hasse) Dowson).—Thirty cultures of *Xanthomonas citri* were established for the study of strains within the pathogen. The pathogen was found to survive in infected leaves for more than 6 months, in sterilized soil upto 52 days and in unsterilized soil upto 9 days only. The reduction in period of survival of the pathogen in soil appeared to be due to antagonistic activity of soil microflora or due to the presence of bacteriophages.

16. *Miscellaneous*

(*a*) *Deficiency disease of guava*.—Experiments on foliage spray, soil application, shoot injection and trunk injection with zinc sulphate were conducted in 14 orchards in Ganera, Hatundi and Chamundia villages in Ajmer. Commercial zinc sulphate was as equally effective as chemically pure zinc sulphate in controlling the disease. In the case of young diseased plants (2-3 years' old), 3 sprayings during the year were found to effectively control the disease, while 5 such operations were necessary in the case of older plants which had been badly affected and had borne little crop for the last few years. Two applications of trunk injection with zinc sulphate at the rate of 15 grains each time cured the diseased branches. Shoot injection, however, cured the injected branches only. In the case of young diseased plants (2-4 years' old), soil application of zinc sulphate at the rate of 4-12 oz. per tree was found to be effective in curing the disease. It, however, took longer time to cure the disease than the foliage spray. In foliage spray, zinc sulphate alone proved to be more effective than when used in combination with copper sulphate,

(*b*) *Blight of mango* (*Macrophoma mangiferae*).—Studies on the factors affecting growth and sporulation of the pathogen and its mutant were undertaken. Both the isolates grew well at pH 5·2-7·0 and temperature of 27-30°C. Ammonium nitrate, ammonium oxalate, magnesium nitrate, calcium nitrate, glutamic acid and peptone were found to be good sources of nitrogen for growth of the two isolates and magnesium nitrate, peptone and histidine for sporulation of the mutant. Glucose, mannitol, sucrose and sarbose supported best growth in case of the parent culture, while glucose, raffinose and soluble starch were the best sources for the mutant. None of the vitamins (thiamine, biotin, inositol, pyridoxine, nicotinic acid and 'K') and trace elements (manganese, iron, zinc and copper) showed any effect on growth and sporulation. However, magnesium and potassium were found to be essential in this respect.

(*c*) *Cultivation of edible mushrooms under Delhi conditions.*—Further investigations on the preparation of spawn and cultivation of edible mushrooms were continued. Besides *Volvaria diplasia* (Indian paddy straw mushroom), *Volvaria volvacea* (Indonesian mushroom) was successfully produced in paddy straw beds with 5-week old spawn. The beds were laid down in glasshouse and manured with gram flour. The temperature during tests ranged from 32°-36°C. Fairly good yield was obtained within about 2 weeks. Attempts are now being made to cultivate the local mushroom which has been brought into culture.

(*d*) *Nematodes in relation to plant diseases.*—A preliminary survey of the Institute Farm crops for plant nematodes was carried out. *Bhindi*, tomato, *brinjal*, bittergourd, wheat, barley, jute, *Luffa acutangula*, *Cyamopsis tetragonaloba* and *Brassica oleracea* var. *botrytis* were found to be severely affected with nematode diseases. *Aphelenchoides* sp. appeared to be associated with the roots of stunted *bhindi* plants, although several other nemas, belonging to the families *Aphelenchoidea*, *Tylenchoidea* and *Dorylaimoidea*, were also isolated from the root zones of *bhindi* plants. Tomato, *brinjal* and jute were found to be affected with root-knot nematodes (*Meloidogyne* spp.). Root-knot nematode of jute appeared to be associated with *Macrophomina phaseoli*.

B. Section of Plant Viruses

16. *Tomato* (*Lycopersicon esculentum* Mill.)

(*a*) *Leaf curl.*—In the varietal resistance tests, all the four U. S. Selections from crosses between tomato and *Lycopersicon peruvianum* (E. C. 2763, E.C. 2764, E. C. 2765 and E.C. 960) proved to be susceptible.

(*b*) *Necrosis.*—The disease could not be transmitted by means of *Myzus persicae*. Further tests with other insects are, however, in progress.

17. *Bhindi* (*Abelmoschus esculentus* Moench.)

Yellow-vein mosaic.—The disease was transmitted to *Abelmoschus tuberculatus* with viruliferous white-flies, but not to *Abelmoschus manihot* var. *pungens* and *Hibiscus penduriformis*. None of the six varieties tested was found to be resistant. Search for alternative hosts of the virus was continued.

18. *Chilli* (*Capsicum frutescens* L.)

Mosaic and Leaf curl.—Field observations taken on about 240 varieties and strains of chilli showed that all of them, except Puri Red, Puri orange, Hyderabad 3, N.P. 62, N.P. 65 and Cuttack Red. were severely affected with mosaic and leaf curl diseases. Varieties of chilli were under test under controlled conditions for resistance to mosaic and leaf curl.

19. *Brinjal* (*Solanum melongena* L.)

(*a*) *Mosaic.*—Studies on the host range of the mosaic virus were continued. The virus was transmitted to *Capsicum frutescens*, *Datura fastuosa*, *D. inoxia*, *Nicotiana tabacum*, *Solanum nodiflorum* and *Physalis peruviana* by juice inoculation. Local necrotic lesions occasionally appeared on *Nicotiana glutinosa*, but normally plants developed severe mosaic interspersed with necrotic spots.

Transmission tests with *Aphis gossypii*, *Myzus persicae* and an unidentified fulgorid were in progress.

(*b*) "*Little-leaf*" *disease.*—Plants of *Datura fastuosa*. *Lycopersicon esculentum*, *Solanum* sp., *S. torvum*, *S. tuberosum* and *Vinca rosea* were inoculated by means of viruliferous jassids (*Euttetix phycitis*) for host-range study. The disease was successfully transmitted to *Datura fastuosa* and *Vinca rosea* only.

20. *Sesamum* (*Sesamum indicum* DC.)

Phyllody.—Cross-inoculation tests by means of *Deltocephalus* sp. have confirmed that phyllody disease in sesamum and sannhemp (*Crotalaria juncea*) is caused by the same virus. The virus was also transmitted to *Crotalaria striata*, *C. alata*, *C. incana* and *C. verrucosa* by means of viruliferous jassids and to *C. verrucosa* and *C. mucronata* by grafting.

In the varietal resistance tests, all the 20 varieties of sesamum (*Sesamum orientale*) as also *Sesamum indicatum* and *S. occidentale* tested either by grafting or through the agency of viruliferous jassids or both were found to be susceptible.

The disease incidence in a number of sesamum varieties grown in the farm area of the Institute varied from 4·5 to 15·8 per cent. *Sesamum alatum* showed 25 per cent infection.

It was further observed that the disease incidence in the early sown crop (5-5, 1 9-5 and 2-6-1955) was higher (23·8 per cent, 14·9 per cent and 12·2 per cent) as compared to the late sown crop (16-6, 4-7, 14-7 and 28-7-1955) where it varied from 3·1 to 8·8 per cent. However, the late sown crop was severely affected with leaf curl disease at a very early stage of growth.

21. *Papaya* (*Carica papaya* L.)

Leaf curl.—Experiments were undertaken to study the relationship, if any, of the age of the host and infection. Plants of different ages (2, 4, 6, 9 and 12 months) were inoculated by viruliferous white-flies, but infection was obtained in 2 to 6

months old plants only. Nine to twelve months old plants, which had been transplanted outside in the field, showed disease symptoms after about 8 months of inoculation.

In the varietal resistance tests, all the four varieties (Ranchi, Bombay, Honeydew and Washington) so far tested have been found to be susceptible.

22. *Cotton* (*Gossypium* spp.)

"*Small-leaf*" *disease*.—Testing of commercial cotton varieties and Indo-American interspecific hybrids for resistance to the disease by grafting were continued. In all 28 varieties of cotton and 8 Indo-American interspecific hybrids were tested during the year under report. Varieties Dhar Cambodia, Buri (C.P.) American, Parbani American and Indore 2 and two interspecific hybrids, namely, 170×CO 2 and 134×CO 2 showed complete immunity. Tests with other varieties are still under observation.

23. *Banana* (*Musa sapientum* L.)

Mosaic (or *Chlorosis*).—Studies on the mode of transmission, host-range and varietal resistance were continued. The virus was again transmitted by mechanical inoculation with juice of diseased banana leaves extracted in phosphate buffer at pH 7·3 to *Cucumis sativus*, but not to papaya or banana.

In host-range studies, *Citrullus vulgaris*, *Cucumis sativus*, *Solanum melongena*, *Physalis peruviana*, *Nicotiana tabacum*, *Carica papaya*, *Zinnia elegans*, *Althaea rosea* and *Tropaeolum majus* did not take infection when inoculated by means of *Aphis gossypii*.

In the varietal resistance tests, banana varieties Tal Chakera, Bargi Bali, China Betha and Kanyal as also *Musa balbisiana* did not take infection through viruliferous *Aphis gossypii*, whereas 12 other varieties and *Musa coccinia* were found to be susceptible.

24. *Sugarcane* (*Saccharum officinarum* L.)

(*a*) *Mosaic*.—Investigations on the occurrence of new strains were continued. Strain Z of the virus was isolated from the cane variety B-6835.

(*b*) "*Grassy-shoot*" *disease*.—The disease was also observed at I. A. R. I. in the ratoon crop of sugarcane variety Co. 1081. The disease was reproduced when 40 setts, obtained from the diseased Co. 419 variety, were planted under insect-proof conditions. Insect transmission tests with scale insects, *Aphis sacchari*, *Aphis maidis* and an aphid species were in progress. The disease was transmitted to 3 plants each of Co. 313 and 419 by the aphid species.

25. *Maize* (*Zea mays* L.)

Mosaic.—Effect of pH and chemicals on the virus infectivity was studied. The virus remained infective between pH 5·7 and 8·0 even after storage for 24 hours at 7°-10°C. It was inactivated with 0·5 per cent formalin after 4 hours interaction and with 40 per cent acetone, 25 per cent alcohol, 60 per cent chloroform and 1 per cent lysol after 24 hours interaction at 7°-10°C.

26. *Sannhemp* (*Crotalaria juncea* L.)

Mosaic.—*Nicotiana tabacum* var. *White Burley*, *Cassia tora*, *Datura stramonium*, *Capsicum frutescens*, *Zinnia elegans* and *Gomphrena globosa* were inoculated for host-range study. The virus produced systemic infection in *Nicotiana tabacum* var. *White Burley* and *Cassia tora* and local necrotic lesions on *Datura stramonium*, *Capsicum frutescens* and *Gomphrena globosa*, whereas *Zinnia elegans* was not infected.

27. *Chinese Sarson* (*Brassica juncea* Var. *rugose* Roxb.)

Mosaic.—The virus was transmitted to *Brassica napus*, *B. alba*, *B. chinensis* vars. *typica*, *Wong Bok* and *Chi-hi-li*, *Lepidium sativum*, *Hesperis matronalis*, *Erisimum* sp., *Iberis* sp., *Mathiola incana*, *Zinnia elegans* and *Nicotiana tabacum* vars. *White Burley* and *Harrison's Special* by juice inoculation. In addition to *Macrosiphum granarium*, *Brevicoryne brassicae* and *Myzus persicae* were found to be vectors of the virus.

28. *Cardamom* (*Amomum subulatum* Roxb.)

"*Foorkey*" *disease.*—The disease is of very common occurrence in West Bengal. It is characterized by the production of numerous slender leafy shoots from the rhizome. The shoots remain extremely dwarfed and leaves become very much reduced in size, chlorotic and slightly curled at the margins. The production of flowering shoot is entirely suppressed.

Investigations on the transmission of the disease and its host-range were undertaken. The disease was transmitted by the banana aphid, *Pentalonia nigronervosa*, but not by *Myzus persicae*. A wild species of *Amomum*, commonly found in the North Kanara District of Bombay State, was successfully infected through viruliferous aphids.

29. *Gooseberry* (*Physalis peruviana* L.)

Mosaic.—Host-range and properties of the virus were studied. The virus was transmitted by sap inoculation and produced systemic mosaic symptoms in *Nicotiana tabacum*, *Petunia hybrida*, *Solanum nodiflorum*, *Datura fastuosa* and *Physalis peruviana*. It produced local necrotic lesions on *Datura inoxia*, *D. stramonium*, *Nicotiana glutinosa* and *N. tabacum*×*N. glutinosa* hybrid and local necrotic lesions followed by systemic mosaic symptoms on *Capsicum frutescens* and *Lycopersicon esculentum*. *Vigna sinensis* was not infected.

The virus was found to be infective after heating for 10 minutes at 90°C., at a dilution of 1,000,000 and after storage for 30 days at 45°C.

30. *Mung* (*Phaseolus aureus* L.)

Yellow mosaic.—A yellow mosaic disease of *mung*, characterized by alternate yellow and green areas on leaves forming a mosaic pattern, was observed. The disease was readily transmitted by *Bemisia tabaci* to *mung* and *urid* (*Phaseolus mungo*), but not by sap inoculation. In host-range studies, the virus was successfully transmitted to *Phaseolus acutifolius* and *Glycine max* through viruliferous white-flies, but not to *Dolichos lab-lab*, *Phaseolus lunatus*, *P. calcaratus*, *P. aconitifolius*, *P. trilobus*, *P. lathyroides* and *P. vulgaris*.

The disease appeared in about 1 per cent plants of *urid*, raised from seed, under insect-proof conditions.

31. *Development of new strains, serological relationship and cross-immunity studies ;*

Spontaneous mutation in potato virus 'X' was recorded, as a result of which seven isolates, showing differences in virulence from the parent strain, were obtained.

The tobacco distortion mosaic virus, which had been filtered out from a tobacco mosaic complex by passage through *Nicotiana glutinosa* last year, was studied. It was transmitted to *Nicotiana paniculata*, *N. companulata*, *N. rustica*, *N. langsdorffii*, *Nicandra physaloides*, *Physalis peruviana*, *Lycopersicon esculentum* and *Nierembergia frutescens* by sap inoculation, but not to *Nicotiana glauca*, *Solanum melongena*, *S. nodiflorum*, *S. tuberosum*, *Datura stramonium*, and *Capsicum frutescens* vars. *longum* and *grossum*. The thermal-inactivation and dilution-end-points were found to be between 72-78°C. and 1 : 60—1 : 200, respectively, and longevity *in vitro* was less than 240 hours at room temperature. The virus was not seed-borne.

The sugarcane mosaic and maize mosaic viruses were found to be related strains of the same virus as judged by the cross protection tests. Similar studies with *Dolichos* enation mosaic and tobacco mosaic viruses as also with *Dolichos* enation mosaic and Southern sannhemp mosaic viruses, however, showed that *Dolichos* enation mosaic virus was not related to the other two viruses.

32. *Isolation and purification of plant viruses and study of their properties*

The viruses of Southern Sannhemp mosaic and *Crotalaria MOSAIC* (Delhi strain) were isolated and purified. The purified preparation of Southern Sannhemp mosaic virus is colourless, highly infectious and shows strong birefringence between crossed polaroids.

33. *Virus-Vector relationship*

The jassid, *Eutettix phycitis*, acquired the virus causing "little-leaf" of *brinjal* from diseased plants in a minimum feeding period of one hour. The nymphs were able to acquire the virus in all the stages except the first instar. *Aphis gossypii* was able to acquire the banana mosaic virus from diseased plants after a feeding period of 10 minutes. In the case of mosaic of *Brassica juncea* (Chinese sarson), a single viruliferous aphid *Brevicoryne brassicae*) was capable of transmitting the virus. The minimum acquisition feeding period was found to be 5 minutes and the minimum period required by the vector to transmit the virus to test plants was 30 minutes. The virus was found to be non-persistent in the vector. The previous results regarding ability of the white-fly to carry three viruses (Yellow-vein mosaic of *bhindi*, Yellow-vein mosaic of pumpkin and mosaic of double beans) simultaneously were confirmed.

34. *Assessment of losses*

The loss due to ground-nut mosaic was assessed under field conditions. The yield of dried nuts from 50 diseased plants was found to be 5 oz. (325 nuts) as against 72 oz. (3045 nuts) from the same number of healthy plants, thus indicating a reduction of yield of about 94·4 per cent.

In the case of papaya mosaic, a yield of 36,000 lbs. per acre was obtained from a papaya plantation in Rahata, where nearly all the 3,559 plants were progressively diseased within 18 months of planting of the crop ; while at Baramati that of 11,633 lbs. per acre was obtained from a plantation which was infected in the seedling stage. A normal papaya plantation should yield on an average 80,000 to 90,000 lbs. of fruits per acre.

35. *Control of virus diseases*

A field experiment on the control of "little-leaf" disease of *brinjal* by spraying with Folidol (Diethyl Paranitrophenyl thiophosphate) was laid out at the Agricultural College Farm, Poona. Three *brinjal* varieties, namely, Surti Gota, Manjri Gota and American Purple were sprayed every week with Folidol for 11 weeks starting from September, 1955, and 4·8, 7·2 and 2·3 per cent disease incidence, respectively, was observed as against 28·7 per cent. in the unsprayed plots.

36. *General*

'Line-pattern' and mosaic diseases of plum were established to be of virus origin as both of them were successfully transmitted by grafting. A disease causing veinal chlorosis and yellowing in young leaves of citrus was also transmitted by bud grafting to sour orange stock. Transmission tests of mango malformation were in progress.

Myzus persicae, *Brevicoryne brassicae* and *Aphis malviodes* were found to be the vectors of mosaic disease of *Hesperis matronalis*. The virus could withstand storage *in vitro* upto 144 hours. Safflower mosaic was transmitted by *Aphis gossypii* and *Rhopalosiphum pseudobrassicae* and *Zinnia* mosaic by *Aphis gossypii* and *Myzus persicae*. *Dolichos* enation mosaic virus was transmitted to *Nicotiana* sp., *Datura stramonium* and *Gomphrena globosa*, but not to *Zinnia elegans*. *Solanum melongena* and *Physalis peruviana* carried the virus symptomlessly. Mosaic of *Datura metel* was transmitted to *Nicotiana paniculata* and *N. companulata*. The viruses causing leaf-curl of linseed and turnip were found to be the same as tobacco leaf curl virus. It was observed that thiosemicarbazide and thiouracil inhibited the multiplication of potato virus X. Investigations on sterility disease of pigeonpea and groundnut mosaic were in progress.

An intensive survey of cultivated plants as also natural flora for the occurrence of virus diseases was continued. Attention was particularly directed to finding alternative hosts of certain important viruses.

C. Section of Systematic Mycology

37. *Taxonomy*

Critical studies of the genera *Cercospora* and *Alternaria* were continued. *Cercospora averrhoae* Petch. *C. buddleiae* Yamamoto, *C. crotalariae* Sacc., *C. curvulina* Speg., *C. desmodii* Ell. and Kellerman, *C. fukushiana* (Matsuura) Yamamoto and *C. ubi* Racib. were found to be new records for India. *C. papayae* Hansford was recorded on *Carica papaya* in Delhi for the first time. *Nicandra physaloides* and *Hyoscyamus niger* were established as new host records for *Alternaria solani* (E.&E.) J.&G. in this country.

Taxonomic studies on Miscellaneous Indian Fungi were in progress. Two new genera *Vasudevella* and *Koorchalomella*, with *V. sporoboli* and *K. oryzae* as type species, respectively, were described. The genus *Vasudevella*, belonging to *Sphaeropsidaceae* (Sphaeropsidales), is characterized by hyaline 2 to 3-celled spores provided with a dichotomously branching cilium at the apex and by pycnidia formed in dried up leaf sheaths and not in any definite spots; while, *Koorchalomella*, belonging to *Tuberculariaceae* (Moniliales), is distinctive by its hyaline single-celled spores with brush-like cilia at each end. The other fungi of interest, not hitherto reported from India, were as follows:

Myxomycetes: *Stemonitis herbatica* Peck on *Musa sapientum*. Ascomycetes: *Karschia* sp. on *Prinsepia utilis*; *Leptosphaeria* sp. on *Ruscus aculeatus*; *Massarina* sp. on *Psidium guyava*; *Mycosphaerella pyrina* E.&E. on *Pyrus communis*; *Mycosphaerella* spp. on *Murraya* sp. and *Thevetia nerifolia*; *Nectria* sp. on *Zanthoxylum alatum*; *Phomatospora* sp. on *Mangifera indica*; *Physalospora* spp. on *Ilex* sp. and *Rhododendron* sp.; *Pleospora* sp. on *Berberis* sp.; *Pringsheimia* sp. on *Oldenlandia* sp.; *Pseudopeziza repanda* (Rob. & Desm.) Sacc. on *Campanula colorata*; *Sphaerotheca* sp. on *Sonchus* sp.; *Sphaerulina* sp. on *Jasminum* sp.; and *Trematosphaeria* sp. on *Jasminum* sp. Basidiomycetes: *Clitopilus undatus* Fr.; *Cortinarius percomis* Fr.; *Hyalopsora sp.* on an unidentified fern; *Marasmius siccus* (Schw.) Fr.; *Panus* sp.; *Puccinia menthae* Pers. on *Micromeria* sp.; *Sphaerotheca* sp. on *Erianthus ravennae*; and *Uromyces* sp. on *Achyranthes aspera*. Deuteromycetes: *Actinodochium concinnum* Syd. on *Quercus* sp.; *Actinodochium* sp. on *Berberis* sp.; *Ascochyta chenopodii* Rostr. on *Chenopodium* sp.; *Ascochyta* spp. on *Canna* sp., *Clerodendron* sp., *Phaseolus mungo* var. *radiatus* and *Vigna sinensis*; *Colletotrichum lagenarium* (Pass.) Ell. & Halsted on *Lagenaria siceraria*; *Colletotrichum* spp. on *Berberis* sp., *Festuca gigantea*, *Hedera helix*, *Phaseolus aureus* and *Polygonum* sp.; *Coniosporium* sp. on *Saccharum officinarum*; *Coremiella* sp. on *Berberis* sp.; *Cytospora rhoina* Fr. on *Mangifera indica*; *Didymosporis* sp. on *Berberis* sp.; *Diplodia* spp. on *Berberis* sp. and *Rhamnus dahuricus*; *Discosia artocreas* (Tode) Fr. on *Pyrus communis*; *Discosia* sp. on *Quercus* sp.; *Ephelis oryzae* Syd. on *Ottochloa* sp.; *Eriosporina* sp. on *Pinus* sp.; *Fusicladium* sp. on *Pyrus pashia*; *Fusoma* sp. on *Pyrilla* sp. parasitising sugarcane; *Graphium aurigenosum* Desm. on *Oryza sativa*; *Hadrotrichum phragmitis* Fuckel on *Phragmitis* sp.; *Helicotrichum* sp. on *Malus sylvestris*; *Hendersonia* sp. on *Citrus*

sp.; *Heterosporium tropaeoli* Bond on *Tropaeolum* sp.; *Leptothyrium* spp. on *Berberis* sp. and *Triumfetta* sp.; *Macrophoma* sp. on *Clerodendron* sp.; *Microdiplodia* sp. on *Malus sylvestris*; *Nigrospora* sp. on *Carissa carandas*; *Pestalotia* spp. on *Cryptomeria japonica* and *Pinus longifolia*; *Phoma* spp. on *Bambusa* sp., *Cycas revoluta*, *Euphorbia* sp., *Leptodermis* sp., and *Xanthium* sp.; *Phomopsis* sp. on *Opuntia* sp.; *Phyllosticta* spp. on *Berberis* sp., *Platanus orientale* and *Saraca indica*; *Rhabdospora* sp. on an unidentified host; *Scolecotrichum* sp. on *Geum urbanatum*; *Septogloeum* sp. on *Eugenia* sp.; *Septonema* sp. on *Thevetia nerifolia*; *Septoria arisaemae* Petch on *Arisaema* sp.; *Septoria* spp. on *Erianthus munja*, *Hedera helix*, *Iris* sp., *Pimpinella diversifolia*, *Populus* sp., *Sanicula europea* and *Vigna sinensis*; *Sphaeropsis* spp. on *Pinus sylvestris* and *Loranthus* sp.; *Stachylidium theobromae* Turcz. on *Musa* sp.; *Stagonospora* sp. on *Prunus amygdalus*; *Stigmina* sp. on *Platanus orientale*; *Stromatographium* sp. on *Mangifera indica*; and *Tetrachia* sp. on *Prinsepia utilis*.

Of these, 4 genera (*Karschia*, *Helicotrichum*, *Stromatographium* and *Tetrachia*) were recorded for the first time in India and about 22 species are new to science.

Biometric studies of *Albugo bliti* on different hosts have provided a basis for dividing the species into at least two inter-specific groups. Cytology of zoospores, flagellation and mode of sporangial germination as also details of oogenesis in respect of certain *Albugo* spp. were worked out.

38. *Herbarium*

In all, 1,501 mycological specimens (both Indian and Foreign) were added to the Herbarium during the year, bringing the total number of accessions to 24,185. One hundred and ten specimens as also 41 coloured plates of important plant diseases were supplied to scientific workers and institutes in the country and abroad. A number of mycological specimens, collected locally and received from different sources, were identified. An exsiccati set on "Indian Cercosporae" was completed and issued to important foreign herbaria and another set on "Indian Uredinales Fascicle III" was under preparation. World literature on the taxonomy of fungi and a list of specimens available in the Herbarium were being compiled.

39. *Indian Type Culture Collection*

The Collection continued to be a member of the International Federation of Culture Collections affiliated to UNESCO. During the period under report 33 fungal and bacterial cultures were added to the Collection, bringing the total number of cultures in stock to 990. A supplement to the list of cultures available in the Collection was prepared. Detailed information regarding each culture is being entered in the descriptive forms. Studies on mineral oil and soil preservation of fungi were continued.

PROGRAMME OF WORK FOR 1956-57

(a) PLANT PATHOLOGICAL INVESTIGATIONS :

(i) Studies on cereal smuts and bunts.

(ii) Determination of physiologic races of *Puccinia graminis-tritici, P. triticina, P. glumarum, P. sorghi, P. simplex, Melampsora lini, Ustilago tritici, Tilletia foetida, T. caries, Neovossia indica* and *Colletotrichum falcatum.*

(iii) Studies on rusts of wheat, barley, oats, maize, sannhemp, safflower, sugarcane, linseed and wild grasses.

(iv) Green ear disease of *bajra.*

(v) *Fruit and vegetable diseases* : deficiency diseases of guava and citrus, blight of mango, and *Alternaria* leaf spot of cruciferous plants.

(vi) Assessment of damage due to certain crop diseases. Aerobiological studies.

(vii) Efficacy of different seed-dressing fungicides : laboratory, glasshouse and field testing of proprietary fungicides and new compounds ; study of ecto- and endo-phytic fungal flora of stored seed grains.

(viii) Testing varieties of crop plants evolved by the Botany Division for their resistance to diseases with particular reference to wheat and barley rusts and smuts, linseed rust and pigeon-pea wilt.

(ix) *Diseases of Sugarcane.*—Factors affecting variation in *Colletotrichum falcatum* and recurrence of the red-rot epidemic ; role of the perfect stage of *C. falcatum* in the origin of new virulent strains ; virulence of mixed inocula of *C. falcatum* isolates ; relative resistance to red-rot of plant and ratoon crops. Evolving of cane varieties resistant to red-rot and smut and studies on the inheritance of their resistance.

(x) Studies on microbial antagonism and antibiotics ; plant tissue culture ; physiology of fungi ; physiology of parasitism of some less specialized plant pathogens ; study of factors affecting virulence of light and dark type isolates of *C. falcatum.*

(xi) *Bacterial diseases of plants.*—Yellow ear rot (Tundu) disease of wheat ; leaf spot of pomegranate ; red-stripe of sugarcane ; citrus canker ; leaf spot of chilli. Survey of bacterial diseases of fruits and vegetables as also association of nematodes with these diseases ; control of bacterial diseases of plants.

(xii) *Radioactive Isotopes.*—Effects of ionising radiations on soil and plant pathogenic micro-organisms ; study of factors involved in the wilting of pigeon-pea plant due to infection by *Fusarium udum.*

(b) Plant Virus Investigations :

(i) Studies on mosaic diseases of *brinjal*, chilli, bottlegourd, sannhemp, maize, sugarcane, groundnut, gooseberry, banana, plum, papaya, *Sarson*, *Datura metel* and *Hesperis matronalis* ; yellow mosaic of *mung* ; yellow-vein mosaic of *bhindi* ; *Dolichos* enation mosaic ; tomato necrosis ; sterility disease of pigeonpea ; phyllody of sesamum and other oilseed crops as also of *Brassica* spp. ; "Smalling" disease of tomato ; leafcurl in chilli, tomato and papaya ; "Foorkey" disease of large cardamom ; "Grassy-shoot" disease of sugarcane ; "Small-leaf" disease of cotton : mango malformation ; "Line-pattern" disease of plum ; virus diseases of citrus and temperate fruits.

(ii) Fundamental studies on virus-vector relationship of "little-leaf" of *brinjal*, sesamum phyllody, banana mosaic and "Foorkey" disease of larger cardamom ; ability of the white-fly to carry more than one virus at a time ; purification of Southern sannhemp mosaic, *Crotalaria* mosaic (Delhi strain), *Dolichos* enation mosaic, bottlegourd mosaic, and *brinjal* mosaic viruses and study of their properties ; inactivation of plant viruses, studies on the development of new strains and cross-protection tests.

(iii) Control of tomato leafcurl, "Little-leaf" of *brinjal* and "Grassy-shoot" disease of sugarcane ; assessment of losses due to papaya mosaic and "Katte" disease of cardamom.

(iv) Survey of plant virus diseases.

(c) Mycological Investigations :

(i) Taxonomic study of new and unidentified collections available in the *Herb. Crypt. Ind. Orient.* ; preparation of exsiccati sets of Indian Fungi, list of fungi deposited in the Herbarium and card indices of species of fungi represented in India ; collection of world literature on the taxonomy of fungi ; study of fungal flora of Delhi ; identification of fungi and disease specimens and taxonomic studies in the genera *Alternaria* and *Cercospora* and maintenance of host index of fungi.

(ii) Maintenance of Indian Type Culture Collection of micro-organisms and their history sheets ; study of methods of preservation of fungi and bacteria.

(d) Miscellaneous :

Routine and advisory ; post-graduate teaching and training of plant protection and short-course students ; assistance and advice to Indian Council of Agricultural Research, Indian Central Sugarcane Committee, Indian Central Cotton Committee, Indian Central Oilseeds Committee, etc., and Intensive Cultivation Scheme, Delhi State ; also, Co-ordination of mycological and plant pathological research.

REPORT OF THE DIVISION OF AGRICULTURAL ENGINEERING

(SHRI R.V. RAMIAH)

GENERAL

(*a*) The objectives of the Division of Agricultural Engineering are generally to foster mechanisation of agriculture, introduce new and improved implements and machines suited to the agricultural practices in India and advise the State Governments and the public on the selection and use of mechanical farm equipment.

(*b*) The following machines and implements were obtained, during the period for tests and trials :—

(i) One 3 row bullock-drawn seed drill with disc type furrow-openers and fluted rollers, width of rows adjustable from 6" to 8" from Messrs. Cossul & Co. Ltd., Kanpur.

(ii) One Garvie New Small-Holder Thresher of size 24" from Messrs. R. G. Garvie & Sons, Aberdeen, U. K. through Messrs. Rallis India, New Delhi.

(iii) One wheat threshing and winnowing machine complete with elevator, pulleys, belts, etc., from Messrs. Friends Own Foundry & Workshop, Ludhiana.

(iv) One one-way horse plough type NW.4 of turnwrest type from East German Stall of Indian Industries Fair, Delhi, 1955.

(v) One chaff cutting machine type F. 113 from East German stall of Indian Industries Fair, Delhi, 1955.

(vi) One Fertilizer Distributor } From Yugoslavian Stall of Indian
(vii) Three hand operated corn shellers } Industries Fair, Delhi, 1955.

(viii) One single-bullock mould-board plough from the Commercial Counseller, Peoples' Republic of China through the Indian Industries Fair, Delhi, 1955.

(ix) One grinding mill (hand operated) from Yugoslavian Stall of Indian Industries Fair, Delhi, 1955.

(*c*) The Division of Agricultural Engineering assisted the other Divisions of the Indian Agricultural Research Institute and advised them about selection, purchase, maintenance and repairs and preparation of indents of engineering spares and equipment. The following amongst these may be mentioned :—

(i) Giving specifications, and making selection of tractors, threshers, etc., for the Division of Agronomy.

(ii) Inspection and approval of furniture required by the Central Office, Library, Hostels, etc.

(*d*) The technical and administrative charge of the Activated Sludge Plant was transferred to this Division with effect from 1.4.56. Formerly, only the repairs of the plant were being looked after by this Division and the plant was in the charge of the Estate Manager of the Indian Agricultural Research Institute.

Recommendations of the Technical Reorganisation Committee

A Technical Reorganisation Committee appointed by the Government of India to look into the technical aspects of the Institute examined the working of this Division also. Regarding the strength of staff in the Division they recommended that a Senior Class I post of Mechanical Engineer in this Division should be abolished and a Class II post of Assistant Engineer (Civil) may be created to work on the problems connected with irrigation, land improvement, drainage and farm structures. They also suggested that a Museum of Agricultural Implements be opened at the Institute and the normal function of the Division should also cover survey of implements in the country and import of animal operated implements and machines to test them for their performance and modify them where necessary.

The recommendations have been accepted by the Government of India and implemented with effect from 1.3.56.

Participation in Exhibitions

The Division participated in the All-India Cattle Show held at Nagore (Rajasthan) from 26th February to 4th March, 1956. A few improved agricultural implements and machines were exhibited and their working and data, etc., were explained to the visiting public. Additional information regarding their source of availability prices, etc., were also given to the enquiring public.

Supply of Working Drawing of Improved Agricultural Implements.

The system of supplying manufacturing blue prints of agricultural implements and machines found useful by actual tests in this Division has met with good response. Several requests for the supply of blue prints were received during the year. These are made available on a nominal payment of Rs. 5/- per set for each implement or machine to private parties and free to the Government Departments. This system enables interested parties to obtain blue prints of implements and machines, which have been found useful after actual tests. The blue prints of the following machines have been supplied during the year under review:—

1. Charsa or water lift with arrangement for automatic discharge of water.
2. Improved Circular Mhote or water lift.

3. Single Row Rice Land Weeder.
4. Guntaka or blade harrow of 4", 8½", 15" and 19½" width.
5. Gatherer for sugarcane crop.
6. Improved Cart Axle with ball bearings.
7. German Chaff Cutter with new features.

SCHEMES

(1) Scheme for Production, Demonstration, Trial and Popularisation of Improved Agricultural Implements

A scheme for Production, Demonstration, Trial and Popularisation of Improved Agricultural Implements was in operation from 3.10.53 to 31.3.56 in this Division. The objectives of the scheme were to popularise some implements that were known to be in use in some parts of our country into the other parts, as well as to introduce some useful foreign agricultural implements and machines into our country. The implements and machines that were included under the scheme are as follows :—

1. Orissa Plough.
2. Guntaka or Blade Harrow.
3. Bullock drawn Bund Former.
4. Mechanical Seed Drill.
5. Olpad Thresher.
6. Green Manure Trampler.
7. Wet Land Puddler.
8. Grain Screen Machine.
9. Pedal Operated Paddy Thresher.
10. (*a*) Rice Land Weeder (Single Row).
    (*b*) Rice Land Weeder (Double Row).
11. Pedal operated wheat thresher.
12. Power thresher (for rice & wheat).
13. Hand operated paddy sheller.
14. Power operated rubber roll rice huller.
15. Rice Polisher.
16. Bullock drawn reaper.

A total of 116 implements and machines were supplied under the scheme to 14 State Governments who participated in the trial and popularisation work.

Of the sixteen items listed above the first ten items are under production in India and a total of 80 implements from this group required by the various State Governments were obtained by this Division through Indian manufacturers.

Five items of machinery (i.e., from item 11 to 15) numbering 29 machines were imported by this Division from Japan and supplied to the various State Governments. The import of the machinery was effected through a firm in Bombay.

Seven bullock-drawn reapers (item No. 16) were imported by this Division from Sweden and distributed to the respective State Governments.

In addition to the above, this Division supplied detailed instructions for operation of the various implements to the State Governments. The instructions on the operation of the implements were prepared on the basis of trials conducted at this Institute earlier and were supplied to the State Governments with a view to facilitate their work. Proformas for recording the observations during the field trials on the implements and machines were also prepared by this Division and supplied to the various State Governments.

Trials of these implements and machines are in progress in many of the States. Duly completed proformas in respect of a few items have already been received from Mysore, Punjab and W. Bengal. The reports received from the various State Governments will be compiled and submitted to the Indian Council of Agricultural Research. The information collected will be very useful to farmers and extension workers in the field. From the work so far done in the scheme, some rice field implements of South India, have come to the notice of agricultural officers and farmers in the North and also some useful Japanese implements and machines and Swedish reapers have been introduced into India.

(2) Testing Station for Tractors, Engines & Pumps

A scheme for testing tractors, engines and pumps came into operation in the Division since June, 1955 on the basis of the recommendations of the Planning Commission. The purpose of the Testing Station is to determine the suitability and usefulness of different types and makes of tractors that are now being imported into India. Mr. S. J. Wright, an expert from the U. K. under the Colombo Plan, visited India during 1955 and submitted his recommendations regarding location and equipment needed by the Testing Station. As no land was available for the Testing Station at Delhi the Government of India examined the possibilities of its location in other places where adequate workshop and land facilities may be available. A committee appointed for this purpose visited Gwalior and Budni, but no decision has so far been taken on the location of the Testing Station.

(3) Scheme for Survey of Indigenous Agricultural Implements in Common use in the Country

A conference of Agricultural Engineers held in January, 1953 recommended that a survey of the indigenous agricultural implements in common use in the country was necessary to provide data for carrying out improvements and that this survey should aim at making a list of the important indigenous implements with their descriptions, illustrations and uses.

In pursuance of the above recommendation a scheme for the survey of indigenous agricultural implements was sanctioned by the Indian Council of Agricultural Research for one year in 19 States, (9 Part 'A', 6 Part 'B' and 4 Part 'C'). This survey was to be undertaken during 1954-55. So far 8 States have submitted their final reports, a few others have completed the survey and their final reports are under preparation and the rest are still busy with their survey work.

At the Indian Agricultural Research Institute, a Mechanical Engineer and one clerk have been appointed in this scheme. Necessary steps have been taken to recruit the remaining staff. The central organisation at the Indian Agricultural Research Institute has to compile and prepare a final report on the scheme.

(4) Scheme for the Establishment of a Museum of Agricultural Implements at the I. A. R. I.

In accordance with the recommendation of the Planning Commission, a scheme for the establishment of a Museum of Agricultural Implements at the Indian Agricultural Research Institute was prepared and submitted to the Government of India by this Division during 1953.

The main objectives are as follows :—

(1) To locate and collect all indigenous and improved implements used in the country including agricultural processing machines, etc., and to provide a store house for them.

(2) To prepare history sheets together with detailed drawings and sketches of all implements displayed in the Museum and furnish such informations to the interested parties, so as to facilitate the introduction of improved and better implements in all parts of the country.

(3) To secure at a later date some power-drawn agricultural implements and machines from abroad that will be considered suitable for use under Indian conditions.

The work in the scheme was not started due to lack of adequate accommodation in the Indian Agricultural Research Institute for this purpose. Detailed plans for the construction of a permanent building for the Museum were prepared and the

building is under construction at present. It is expected that the construction will be completed by the end of this year after which the staff will be appointed and the work started.

(5) Scheme for Import & Trial of Agricultural Implements

On the basis of the recommendations made by the Planning Commission, a scheme for the import and trial of foreign agricultural implements was prepared by this Division. The main object of the Planning Commission's recommendations and the scheme was to test under our local conditions the bullock or horse-drawn implements used in other countries and to modify them, if required to suit the local conditions. The scheme was considered by the Agricultural Engineering Committee of the Indian Council of Agricultural Research.

It was desirable to obtain the opinions of the State Departments of Agriculture whether they would try the implements proposed to be imported under the scheme and also whether similar implements were already in use in their States. In the latter case, they should be requested to specify the different machines and implements in use in their States and give full details of machines and implements which should be imported and which should be purchased from the indigenous sources. Therefore, a circular letter along with a copy of the scheme has been issued by this Division to the State Departments of Agriculture of the 18 States with a request to state their views and to furnish the information required.

The replies of the State Governments are awaited at present. Further action on the scheme will be taken after receipt of their replies.

(6) Procurement of Implements and Machines from Japan for Purposes of Trial & Popularisation

A sum of Rs. 1,87,000 was sanctioned by the Ministry of Food and Agriculture (Agriculture) to purchase suitable agricultural implements and machines from Japan for purposes of trial and popularisation in our country.

It is intended to utilize the above mentioned amount for the purchase of four sets of 24 items of implements and machines. While one of the sets will be retained at this Institute, the remaining three sets will be distributed to State Governments of West Bengal, Bombay and Mysore for trial and demonstration in their regions.

Arrangements are being made to procure 15 items of implements and machines directly from Japan. The import is being effected through the Indian Liaison Mission in Tokyo. The matter is being considered by the Supply Mission at present.

As regards the remaining 9 items of implements and machinery this Division has undertaken to procure them. Action is in progress at present through the Indian representatives of Japanese firms.

RESEARCH AND TESTING

(A) Experiments on Cultivating Implements

(i) *Method of Selection of Mould-Board ploughs*

The mould-board which is a bent or curved metallic plate is an important part of the improved iron and steel plough of western origin. The mould-board of the plough receives the furrow slice of earth after it is cut by the plough-share and the soil is partially or fully turned over. The mould-board also pulverizes the soil to a required degree. The curvature and the shape of the mould-boards are responsible for the degree of soil inversion and pulverisation. About 750 types of mould-boards were being manufactured in the U. K. alone by the firms dealing in farm machinery to suit various soil conditions and cultural practices in different parts of that country. It is difficult for the farmers or the agricultural officer to select a suitable mould-board out of a large group to suit particular requiremets. To overcome this difficulty efforts have been made in this Division to standardize mould-board into 6 main shapes. These shapes have been indicated by numbers as 1, 2, 3 and so on. The shapes of the mould-boards vary from a long gradual to a short and abrupt curvature.

The No. 1 mould-board has less degree of curvature and is of general purpose type. The general purpose mould-board simply turns the furrow slice without shearing and twisting the soil, due to its long gradual curvature. It is suitable for ploughing operations where it is required to turn the furrow slice without disturbing or breaking the soil.

On the other extreme the No. 6 mould-board which is the digger type has an abrupt curvature. The function of the digger bottom is to plough deep and to invert the furrow slice completely. It pulverizes the soil to a greater extent than the general purpose type depending upon the soil type and its moisture content. It will bury the trash and stubbles of the previous crop. Two sets of such mould-boards (consisting of 6 different shapes) have been prepared to fit on a commonly used plough for purposes of field trial.

These six mould-boards are so prepared that they can be interchangeably used on the same bottom, one after another of any medium sized plough with the help of special bolts and nuts. It is possible from this method to select a suitable type for any purpose by conducting actual field trials.

(ii) *Method of Hitching of Mould-Board Ploughs*

Many of the Indian firms, engaged in the production of mould-board ploughs are manufacturing them with short wooden or steel beams on the western design. The ploughs with short beams are suitable for western countries in view of the fact that they are hitched to the harnesses and pulled by horses. But in India the condition is different as the main source of farm power are bullocks which are used to walk in a pair with yokes on their necks.

An important factor in operating a walking plough with success is the use of the correct hitch with a suitable harness or yoke. The pulling force should be applied in the line of draft or in the direction of the pull required for getting over the forces of external resistance on the plough to get the best results.

Experiments were conducted in order to find out whether the plough with long wooden beam or the plough with short one is more efficient under the Indian conditions of farming. During the course of the experiment it was observed that the pull exerted with the long wooden beam was 290 lbs. as against 320 lbs. with plough with short steel beam for the same work done by the plough. 269 lbs. out of the total draft of 290 lbs. in the former case was usefully employed in shearing and pulverising work while in the latter case only 257 lbs. (out of an exerted draft of 320 lbs.) could be made use of for useful work. It was also observed that the downward force which the ploughman has to exert to keep the plough in a stable position is 109 lbs. for the plough with long wooden beam and 190·50 lbs. for the other one.

Hence the plough with a short beam is not convenient for use in India so long as the yokes are not replaced by the harnesses on the bullocks. Both the bullocks and the ploughman will have to exert higher draft for doing the same amount of work which can be done with lesser efforts if the plough has a long beam.

Therefore, the short wooden or steel beam should be avoided and only long beam should be used in the interest of the ploughman, the bullocks and the efficiency of the plough, so long as yokes are used with bullocks, as at present.

(iii) *Trial of a "Hand Hoe"*

At the instance of the Head of the Division of Agronomy, Indian Agricultural Research Institute, a hand hoe was tested in the field for its performance regarding hoeing and removing the weeds. The hoe was simple in construction. It had a 6′ long bamboo stick of $1\frac{1}{2}$″ dia. to one end of which a shovel made of steel was fitted.

The hoe was tested in the field where cow-peas were sown in lines. It took one hour to weed out an area of 50′× 25′ by one man. The implement was then tested in the cultivated fallow land where it took three hours twenty minutes to hoe the same area (50′×25′). During the trials it was observed that the hoe could not dig out weeds like Motha, Dub, etc. Further trials will be conducted in vegetable plots for which the implement had been designed.

(B) Harness for a single Bullock for Field Work

Most of the farm work and agricultural operation in India are carried out by animal power such as bullocks, buffaloes and camels. Bullocks are used mostly

in pairs and camels are used single. The buffaloes are used both single and in pairs. Single bullocks too are known to be used for different operations like working oil ghanis and pulling carts in the urban areas for transport of materials, etc.

There is a necessity for a single bullock yoke or harness for farm work. Consequently a harness has been designed for a single bullock for hitching field implements. Preliminary trials have been conducted with 6" plough and the results are promising. A bullock has been trained on the implement, with the newly designed harness. The harness will be tested for various farm operations specially ploughing under the actual field conditions.

(C) Experiments on Seed Drill & Fertilizer Distributing Machines

(i) *Bullock-drawn Implement for Placement of Fertilizer*

With a view to design a fertilizer distributor-cum-seed drill, efforts have been made to develop a single row automatic bullock drawn machine. The machine, which is made mostly of wood except few steel parts, is fitted on a frame mounted on two wheels. The fertilizer dropping mechanism consists of a wooden worm which revolves in a wooden casing. Two fertilizer boxes with automatic feeding devices are mounted on either side of the seed box so that fertilizer could be dropped on both sides of the seeds. Arrangements are made so that the fertilizer and seeds can be dropped simultaneously or fertilizer or seed alone. The amount of fertilizer and seed can be regulated independently of each other. Preliminary field trials have been taken. Futher trials will be conducted for *rabi* sowing.

(ii) *Improvements to an Indian made seed drill*

There are few makes of bullock-drawn automatic seed drills available in India at present. One of them, which is known in the Punjab had no handy or efficient arrangement to withhold the dropping of seeds at turnings in the fields. Experiments were conducted to simplify the present clutch system to make it more effective and convenient. A simple clutch system has been provided on one of the wheels which could be operated conveniently by the operator sitting on the seed box. After necessary modifications the machine was tested under actual field conditions and the preliminary trials proved successful. The simple hand operated clutch can withhold dropping of seeds when not wanted.

(D) Experiments on Harvesting Machines

Bullock-drawn Reaper

While testing the bullock-drawn reaper developed last year in the Division, it was observed that when the machine was operated, the vegetation clogged with the gears of the working mechanism and the wheels slipped. To overcome these difficulties efforts have been made to increase the diameter of the wheels to have more ground clearance, and the working mechanism has been consolidated. Lugs have been fitted on the face of wheels to minimize slippage. A long wooden beam has also been fitted for hitching the reaper to the yoke of bullocks. The working model is ready and will be tried for cutting green fodder like berseem, etc.

(E) Experiments on Threshing Machines

A power Operated Thresher

A thresher which produces Bhusa and grain in one operation, purchased from the Friends Own Foundry, Ludhiana has been tried on oats and wheat. It has also been tried and demonstrated in the villages of Nilothi and Nangloi near about Delhi. There was no breakage of grain and the bhusa formed with this machine was quite small. The machine was worked with a Ferguson tractor. The output of the machine per day of 8 hours was 4,000 lbs. of grain and the fuel (kerosene) consumption of the tractor during this trial was approximately a gallon an hour. The performance of the machine has been considered by the farmers as very satisfactory.

The preliminary testing of the thresher gave the following results.

Duration of trial in hours.	Working speed of threshing drum in R. P. M.	No. of men employed.	Consumption of fuel for a day of 8 hours in gallons.		Output per day of 8 hours in lbs. (grains).
			Powerine.	Petrol.	
6½	600	One driver two men.	6·15	0·25	3,446
8½	600	Do.	7·25	0·28	3,878

The thresher is being put to extensive tests for its output and performance.

(F) Experiments on Feed Preparing Machines

(i) *Trial of a Hammer Mill*

A hammer mill purchased from Messrs. T. E. Thomson & Co., Calcutta was put to test for grinding oats, maize, green fodder, etc. The following observations were made when the hammer mill was tried for grinding oats and maize :—

Feed.	Time of operation.	Amount ground in lbs.	Output in lbs./hour.
Oats . . .	50 minutes	410	492
Maize. . .	11 ,,	82	451

(The mill was driven by an Allis Chalmers Tractor 'C' Model and was operated at 2250-2600 R.P.M.)

The grinding was satisfactory for cattle feed. When the hammer mill was tried to cut the green silage and to reduce the size of wheat or barley straw to small pieces it could not give satisfactory results. Increasing the size of screen or variation of speed were tried but the results were not satisfactory and the mill was choked immediately after feeding it with silage. As such the mill, in its present form, is not considered suitable for cutting green silage.

(ii) *Trial of a hand operated grinding machine*

The "POBEDA" hand operated grinding machine, purchased from the Yugoslavian Stall at the Indian Industries Fair has been tried for grinding maize and peas. The following observations were made.

Feed opening.	R. P. M.	Output in lbs.	Time in minutes.	Remarks.
	Maize.			
Maximum . . .	46	9·7	5	Rough
Partial . . .	43	4·7	5	Course
Minimum . . .	29	3·4	5	Fine
	Pea			
Maximum . . .	50	7·8	5	Rough
Partial	47	2·4	5	Course
Minimum . . .	40	2·3	5	Fine

In case of both the grains, best results were obtained when the hopper opening was kept at the minimum though the output was decreased to 25 per cent approximately. The grinder was easy to operate and one man could easily grind 27 seers of maize and 13·5 seers of peas in one hour. The preliminary trials have been successful. The grinder will be tested for grinding other grains as gram, jowar, etc.

(G) Experiments on Spraying & Dusting Machines

Sprayers and dusters

Experiments have been conducted to develop a bullock-drum-manually operated machine for spraying and dusting chemicals for field crops. The mechanism is simple and is easy to operate. A small plunger pump has been fitted inside a drum which serves as a container for the spraying liquid. The whole equipment is mounted on a wooden frame which is supported on two wheels. A seat has been provided for the operator. Under the wooden frame a driving mechanism is provided with the help of cycle crank, and the chain is similar to that of an ordinary bicycle. A hook is provided on the frame for hitching the machine to the bullocks. The operator who will pedal the pump with his feet will control the bullocks simultaneously. The preliminary trials have shown that one man can develop sufficient pressure to spray materials to a range of 30 feet. Efforts are in progress to increase the efficiency of the mechanism.

(H) Experiments on Water lifts, etc.

Trial of circular Mhote

This is a water lifting device operated by means of bullock power. The bullocks move in a circular path adjacent to the well from which water has to be lifted. Ropes from the mhote are passed over two sets of differential drums fixed on the top of the well.

The differential drum consists of two drums of different diameters having a common axle of rotation. Thus the drums rotate integrally. The drums have side flanges to prevent the ropes from going out. When the axle of the drum is rotated by bullock power, this winds the drum which lifts a bucket of water. Thus the whole operation is cyclic and automatic. Two sets of differential drums are used to balance the load on the bullocks. Initial trials on one differential drum were conducted and these preliminary trials were satisfactory. Further trials are in progress. It is hoped that the differential drum will enable greater depths from which water could be lifted than at present by this mechanism and also simplify the entire process.

(I) Trials of Tractors XT3-7

Two Russian Tractors XT3-7 have been tested last year. The tests conducted at the Institute have included all normal farming operations and as a stationary power unit. From field tests, it was found, that the tractor consumed 0·66 gallons

of fuel per hour in 2nd and 3rd gear while ploughing, at 17 per cent. wheel slippage and could plough 0·35 acres per hour. For stationary works, the fuel consumed varied from 0·75 gallons per hour for pumping water to 0·24 gallons per hour at light load like shelling of maize.

One of the tractors was later on withdrawn by the Central Tractor Organisation. The other was retained for extensive use over the summer months at the Indian Agricultural Research Institute. It was sent to villages under the Intensive Cultivation Scheme, where it was subjected to continous working during the summer months for ploughing threshing and levelling for road making purposes.

The tractor has been in use for about 250 hours till now and has worked satisfactorily. It can be of use to farmers with small holdings who can use it for normal farm transport as well as other farm work.

(J) Axles with Ball Bearings for Country Carts

For purposes of trial and comparison with ordinary cart axles, some improved hubs and axles developed by the National Emporium, Roorkee, have been secured. 5 sets of the improved axles with ball bearings have been despatched to Punjab and 5 sets to Bihar for tests and trials. Work of testing and collecting the data has been taken in hand with a view to compare them with ordinary axles used in country carts. An apparatus is being built, for measuring the power consumption when different types of axles and bearings are used on cart wheels. The electrical method for measuring power input has been adopted. By using this apparatus, it is expected to find any difference in the pull or force needed to draw carts with or without ball bearings on the axles.

(K) Intensive Cultivation Scheme

Under the Intensive Cultivation Scheme the following demonstration works were carried out in the villages during the year under report :—

Tractor ploughing in weedy lands	30 acres.
Ploughing with mould-board ploughs and five tined cultivators	553 acres.
Wheat sowing by 5 & 3 row seed drills	38 acres.
Paddy shelling and rice polishing	29½ maunds.
Wheat threshing by Olpad threshers	1,451 maunds.
Wheat threshing by Ludhiana Thresher	520 maunds.

The village blacksmiths have been encouraged to fabricate Olpad threshers and mould-board ploughs locally. As a result a large number of farmers are taking up the improved implements

PROGRAMME OF WORK FOR 1956-57

1. Continued experiments on Winnowing fans and grain cleaners.
2. Design and fabrication of bullock operated implements for placement of fertilizer.
3. Fabrication of sprayers and dusters –bullock drawn.
4. Experiments on developing a single bullock harness.
5. Development of a bullock drawn reaper.
6. Modifications to Circular "Mhote".
7. Continued trials on "Charsa".
8. Designing of a cheap bullock operated seed drill.
9. Development of hand dibbler and markers.
10. Experiments on using tractors for rice land cultivation.
11. Testing of threshers obtained from U. K.
12. Testing of Ludhiana Thresher.
13. Testing of "Twose" cultivator.
14. Testing of improved cart axles.
15. Any other item suggested by the Ministry.

SCHEMES.

1. Tractor Testing Scheme.
2. Museum of Agricultural Implements.
3. Survey of Indigenous Implements in use in the country.
4. Production, Demonstration, Trial and Popularisation of Improved Agricultural Implements (compilation of reports from the States on the performance of the implements supplied to them).
5. Establishment of four research-*cum*-testing centres for agricultural implements on a regional basis (Second Five-Year Plan Scheme sponsored by the Indian Council of Agricultural Research).

PART III—APPENDICES

APPENDIX I

Gazetted staff of the Indian Agricultural Research Institute during 1955-56

1. Director	Dr. B. P. Pal, M.Sc., PH.D. (Cantab.), FLS, FBS, FNI.
2. Personal Assistant to Director	Shri J. M. Banerjee, M.A.
3. Librarian	Shri N. N. Chatterjee, B.Sc., Diploma in Librarianship, Diploma in French, German and Russian.

DIVISION OF AGRONOMY

1. Head of the Division and Principal, Central College of Agriculture.	Dr. F. J. Mirchandani, M.Sc., PH.D. (Lond.). A.I.Sc. (upto 29-7-55 A. N.).
Head of the Division of Agronomy .	Dr. P. C. Raheja, M.Sc., PH.D. (from 29-7-55 A.N.).
2. Agronomist	Shri S. Sen, M.Sc.
3. Agronomist	Shri A. R. Khan, B.Sc. (Ag.), M.Sc. (Wiscon.), P. G. (Agro.) (Officiating).
4. Agronomist	Dr. J. N. Sharma, M.Sc. (Ag.) (Offg. from 18-2-55).
. Asstt. Agronomist	Shri J. J. Chandnani, M.Sc. (Agr.) (upto 18-10-1955).
6. Asstt. Agronomist	Shri R. D. Verma, B.Sc. (Ag.), B.Sc. (Hons. Edin.) (upto 22-2-1956).
	Shri Hardharan Singh (from 15-10-1955 A.N.).
7. Asstt. Agronomist	Shri Sher Singh, B.Sc. (Ag.), Assoc. IARI (Officiating).
8. Asstt. Agrostologist	Shri P. M. Dabadghao, M.Sc. (On deputation with I. C. A. R.). (Post transferred to Botany Division from 1-3-1956.)
9. Assistant Statistician . .	Dr. P. N. Saxena, M.A., PH.D.

DIVISION OF BOTANY

1. Head of the Division . . .	Dr. S. M. Sikka, M.Sc., PH.D. (Lond.), Assoc. IARI.
2. Plant Physiologist	Dr. R. D. Asana, M.Sc., PH.D., D. I. C.
3. Geneticist	Dr. A. B. Joshi, M.Sc., PH.D., Assoc. IARI.

APPENDIX I—*contd.*

Gazetted staff of the Indian Agricultural Research Institute during 1955-56

DIVISION OF BOTANY—*contd*

4. Cytogeneticist	Dr. P. N. Bhadura, M.Sc. Ph.D., FNI (relieved on 5-4-1956 A.N.). Dr. M. S. Swaminathan, B.Sc., B.Sc. (Agri.), Ph.D. (Cantab.), Assoc. IARI (from 5-4-1956 A.N.).
5. Systematic Botanist . . .	Dr. D. Chatterjee, M.Sc., Ph.D. (Lond.) (relieved to join his new post as Superintendent, Botanical Garden, Calcutta).
6. Wheat Breeder (Coordinated Wheat Rust Control Scheme)	Dr. G. S. Khush, M.Sc., Ph.D., Assoc. IARI.
7. Assistant Geneticist	Shri H. B. Singh, M.Sc., Assoc. IARI (upto 25-11-1955).
8. Asstt. Geneticist . . .	Dr. N. L. Dhawan, M.Sc., Ph.D. (upto 9-10-1955).
9. Asstt. Plant Physiologist (Coordinated Scheme for investigation of micro nutrients).	Shri V. S. Mani, M.Sc.
10. Asstt. Plant Physiologist . .	Shri I. J. Mulliani, M.Sc.
11. Asstt. Wheat Breeder (Coordinated Wheat Rust Control Scheme).	Vacant
12. Asstt. Cytogeneticist (Scheme on cytological studies on oilseeds).	Shri S. S. Rajan, M.Sc.
13. Asstt. Cytogeneticist . . .	Dr. M. S. Swaminathan, B.Sc., B.Sc. (Agr.), Ph.D. (Cantab.), Assoc. IARI (upto 5-4-1956).
14. Superintendent of Gardens (Horticulture Section).	Shri Ramesh Chandra, B.Sc. (Ag.).
15. Asstt. Agrostologist	Shri P. M. Dabadghao, M.Sc. (on other duty).
16. Seed Testing Officer (Scheme for setting up of Seed Testing Station)	Dr. N. L. Dhawan, M.Sc., Ph.D. (from 10-10-1955).

DIVISION OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

1. Head of the Division . . .	Dr. S. P. Raychaudhuri, M.Sc., Ph.D. (Lond.), D.Sc. (Lond.) (Cal.), F. R. I. C.
2. Agricultural Chemist . . .	Vacant.
3. Soil Survey Officer	Dr. R. V. Tamhane, B. Ag., Ph.D. (Lond.) (upto 26-7-1955).* Dr. K. V. S. Satyanarayana, B. Sc. (Agr.), Ph.D. (from 23-2-1956).
4. Biochemist	Dr. N. B. Das, M.Sc., Ph. D.

APPENDIX I—*contd.*

Gazetted staff of the Indian Agricultural Research Institute during 1955-56

DIVISION OF SOIL SCIENCE—*contd.*

5. Organic Chemist . . . . . L. K. Crews, B.Sc. (Pom. Tech.), M.Sc. (Hons.)

6. Experimental Physicist . . . . . [illegible], M.Sc., Ph.D. (Lond.), D.Sc.

7. Soil Scientist (To conduct [illegible] determination of [illegible] and fertilizer use) . . . . . [illegible], B.Sc., [illegible] (upto 31-7-1956)

8. Agronomist (Ditto) . . . . . [illegible], M.Sc., [illegible] (upto 20-7-1956)

9. Cartographer (Ditto) . . . . . [illegible], A.S.I. (upto 20-7-1956)

10. Statistician (Junior Class II) . . . . . [illegible] (upto 20-7-1956)

11. Assistant Agricultural Chemist . . . . . [illegible], M.Sc., A.I.C., I.A.R.I.

12. Asstt. Soil Microbiologist . . . . . [illegible], M.Sc., Ph.D., A.I.C., I.A.R.I.

13. Asstt. Soil Physicist . . . . . [illegible], M.Sc., Ph.D. (Lond.), D.I.C.

14. Asstt. Soil Survey Officer . . . . . [illegible], B.Sc. (Agr.), Ph.D., Assoc. I.A.R.I. (upto 31-7-1956)
[illegible], M.Sc., D. Phil. (from 23-2-1956).

15. Asstt. Soil Survey Officer . . . . Shri R. S. Murti, M.Sc.

16. Assistant Biochemist (Scheme for studies on the chemical composition and nutritive value of [illegible]). [illegible] M.Sc., Ph.D.

17. Asstt. Organic Chemist . . . . Dr. [illegible] M.Sc., Ph.D.

18. Asstt. Soil Chemist . . . . . Dr. C. N. [illegible], M.Sc., Ph.D., D.Sc. (Lond.), F.R.I.C.

19. Asstt. Physical Chemist . . . . Shri L. Ramamurthi, M.Sc., A.R.I.C. (Lond.), Assoc. I.A.R.I.

20. Asstt. Soil Chemist . . . . . Dr. B. V. [illegible], M.Sc., Ph.D.

DIVISION OF ENTOMOLOGY

1. Head of the Division . . . Dr. T. B. Venkata, M.A., Ph.D. (Lond.), D.I.C., F.R.E.S., F.Z.S.I.

2. Systematic Entomologist . . . . Dr. M. C. Ramdas Menon, M.Sc., Ph. D. (from 24-3-1956).

3. Insect Ecologist . . . . . Dr. S. Prakash, B.Sc. (Hons.), M.Sc., Ph.D. (Lond.), D.Sc., F.P.S., F.Z.S.I.

4. Toxicologist . . . . Vacant.

5. Assistant Systematic Entomologist . Shri S. M. Chatterjee, M.Sc. (upto 20-1-1956).

APPENDIX I—*contd.*

Gazetted staff of the Indian Agricultural Research Institute during 1955-56

DIVISION OF ENTOMOLOGY—*contd.*

6. Asstt. Insect Ecologist . . .	Shri H. N. Batra, B.Sc. (Agri.), Assoc. IARI (upto 7-12-1955).
7. Assistant Toxicologist . . .	Dr. Rattan Lall, M.Sc., PH.D. (upto 7-12-55).
	Shri S. N. Chatterjee, M.Sc., Assoc. IARI. (from 8-12-1955).

DIVISION OF MYCOLOGY AND PLANT PATHOLOGY

1. Head of the Division . . .	Dr. R. S. Vasudeva, D.Sc. (Lond.), PH.D. (Lond.), DIC. FNI.
2. Systematic Mycologist . . .	Dr. B. L. Chona, B.Sc., Ph.D. (Lond.), DIC.
3. Mycologist (Coordinated Wheat Rust Control Scheme).	Dr. R. Prasada, M.Sc., D.Sc. (Agra).
4. Asstt. Plant Pathologist . . .	Dr. M. R. S. Iyengar, M.Sc., PH.D. (Offg.).
5. Asstt. Plant Pathologist . . .	Dr. M. L. Gattani, M.Sc., PH.D. (Minn.) (on leave out of India). Dr. Kishan Singh, M.Sc., PH.D. (U. S. A.) (from 12-4-1956).
6. Asstt. Virus Pathologist . . .	Dr. S. P. Raychaudhuri, M. Sc., D. PHIL. (Cal.), FLS., Assoc. IARI. (upto 16-11-1955). Shri H. S. Sahambi, M.Sc. (from 14-3-1956).
7. Asstt. Plant Bacteriologist . .	Dr. M. K. Hingorani, B.Sc. (Ag.), PH.D. (Minn.), Assoc. IARI. (upto 16-11-1955).
	Shri S. D. Gera, M.Sc. (from 6-4-1956).
8. Herbarium Keeper	Shri R. L. Munjal, M.Sc. (from 3-5-1956).

DIVISION OF AGRICULTURAL ENGINEERING

1. Head of the Division . . .	Shri R. V. Ramiah, B.E. (Mech.), M.Sc. (Iowa), MASAE.
2. Assistant Engineer	Shri J. S. Manku, B.Sc. (Elec. Mech. Engg.), AMIE.
3. Assistant Engineer . . .	Shri R. P. Singh, B.Sc. (Agril. Engg.), M.Sc. (Agr.).

AGRICULTURAL RESEARCH SUB-STATION, KARNAL

1. Asstt. Agronomist	Shri B. D. Gangulee, B. Sc. (Ag.).

BOTANICAL SUB-STATION, PUSA

1 Superintendent	Shri M. D. Nandkeolyar, M.Sc.

APPENDIX I—*contd.*

Gazetted staff of the Indian Agricultural Research Institute during 1955-56

Coordinated Wheat Rust Control Scheme

(a) *Simla Centre*

1. Asstt. Wheat Breeder	Dr. S. P. Kohli, M.Sc. Ph.D.
2. Asstt. Mycologist	Shri V. G. Lele, M.Sc. (Agri. Bot.).
3. Asstt. Mycologist	Shri R. L. Munjal, M.Sc. (upto 2-5-1956). Shri D. P. Misra, M.Sc. (from 3-5-1956).

(b) *Indore Centre*

1. Asstt. Wheat Breeder	Shri V. S. Mathur, M.Sc. (Agri.).

(c) *Wellington Centre*

1. Asstt. Wheat Breeder	Shri V. K. Srinivasan, M.Sc.
2. Asstt. Mycologist	Shri L. M. Joshi, M.Sc.

(d) *Pusa Centre*

1. Assistant Wheat Breeder	Shri S. Kedarnath, M.Sc. (on special leave out of India from 12-8-55).

2ND FIVE YEAR PLAN SCHEMES

Project for Irrigation Investigation

1. Agronomist	Shri J. J. Chandnani, M.Sc. (Agri.) (with effect from 19-11-1955).
2. Asstt. Agronomist	Shri R. T. Gandhi, B.Sc. (Agric.), Assoc. IARI (with effect from 19-11-1955).

Project for setting up Post-Graduate course in Agricultural Extension

1. Professor of Agril. Extension	Vacant.
2. Agril. Development Officer	Shri S. R. Obherai, B.Sc. (Agri.), Assoc. IARI (with effect from 19-11-1955).

Scheme for Investigation on Weed Control

1. Agronomist	Shri R. D. Verma, B.Sc. (Agri.), B Sc. (Hons., Edin.) (with effect from 23-2-1956).
2. Asstt. Agronomist	Vacant.

Tractor Testing Station

1. Technical Officer	Shri G. Vedantiah, Bachelor's degree in Mech. Engineering (with effect from 14-6-55).

Survey of Indigenous Agril. Implements

1. Mech. Engineer	Shri J. R. Badola, B. Sc. (Agric. Engg.) (with effect from 1-6-1956).

APPENDIX I—*contd.*

Gazetted staff of the Indian Agricultural Research Institute during 1955-56

Establishment of Plant Introduction and Exploration Organisation (Botanical Portion—Delhi Centre)

1. Plant Introduction Officer	Vacant.
2. Asstt. Botanist	Shri S. P. Mital, M.Sc., Assoc. IARI (Offg.).

Central Vegetable Breeding Sub-Station, Katrain

1. Vegetable Specialist	Shri H. B. Singh, M.Sc., Assoc. IARI (with effect from 26-11-1955) (Offg.).

Maize Scheme (Botany Division)

1. Asstt. Economic Botanist	Shri Amir Singh, M.Sc. (Agri.) (with effect from 18-7 1955).

Scheme for Setting up of Seed Testing Station

(*Botany Portion*)

1. Seed Testing Officer	Dr. N. L. Dhawan, M.Sc., Ph.D. (Minn.), Assoc. IARI (with effect 1-10-1955).

Scheme for the use of Radio active Isotopes in Cytogenetic Studies

1. Assistant Cytogeneticist	Dr. H. K. Jain, B. Sc. (Hons.), Ph.D., Assoc. I. A. R. I. (with effect from 6-6-1956).

Scheme for the Establishment of Unit for Embryo Culture

1. Assistant Cytogeneticist	Shri S. Ramanujam, B.Sc. (Hons.), Assoc. I. A. R. I. (with effect from 15-9-1955).

Scheme for Investigation for Assessment of soil Fertility

1. Soil Scientist	Dr. N. P. Datta, M.Sc., Ph.D. (Offg. from 1-3-1956).
2. Asstt. Soil Chemist	Dr. B. V. Subbiah, M.Sc., Ph.D. (with effect from 1-3-1956).

APPENDIX I—*contd.*

Gazetted staff of the Indian Agricultural Research Institute during 1955-56

ALL-INDIA SOIL SURVEY SCHEME, I. A. R. I.

(a) *Delhi Unit*

1. Stores Officer	Shri K. C. Gupta, B.A. (with effect from 18-7-1955).

(b) *Bangalore Unit*

1. Soil Correlator	Dr. S. V. Govindarajan, B.Sc., Ph.D. (with effect from 3-2-1956).

SCHEME FOR EXPANDED SOIL TESTING SERVICE UNDER SUPPLEMENTAL TO OPERATION AGREEMENT No. 4.

1. Special Officer	Dr. R. V. Tamhane, B. Agr., Ph.D. (Lond.) (with effect from 27-7-1955).

SCHEME FOR WORKING ELECTRON MICROSCOPE

1. Assistant Physicist	Shri S. C. Mehta, M.Sc. (with effect from 25-4-1956) (Offg.).

SCHEME FOR CARTOGRAPHIC LABORATORY FOR SOIL MAPPING

1. Cartographer	Shri L. M. Mathur, M.A. (with effect from 1-3-1956).

TERMITE SCHEME

1. Assistant Entomologist	Dr. H. J. Bhambani, B.Sc., Ph.D., Assoc. I. A. R. I. (with effect from 8-12-1955).

SCHEME REGARDING RESEARCH ON INSECT PHYSIOLOGY

1. Insect Physiologist	Dr. Rattan Lal, M.Sc., Ph.D., Assoc. I. A. R. I. (with effect from 8-12-1955).

UNIT FOR BIOLOGICAL TESTING AND CERTIFICATION OF INSECTICIDES

1. Assistant Entomologist	Shri M. G. Jotwani, B.Sc., Assoc. IARI (with effect from 8-12-1955).

APPENDIX I—*contd.*

Gazetted staff of the Indian Agricultural Research Institute during 1955-56

Scheme for Establishing a Unit for Storage Pest Ecology

1. Assistant Entomologist	Shri P. B. Mukherjee, B.Sc., Assoc. I. A. R. I. (with effect from 8-12-1955).

Scheme for Survey of Beneficial Parasites of Pests of Agricultural Crops

1. Assistant Entomologist	Shri B. R. Subba Rao, B. Sc., Ph.D., Assoc. I. A. R. I. (with effect from 8-12-1955).

Scheme for Entomological Investigation with the help of Radio-active Isotopes

1. Entomologist	Shri S. M. Chatterjee, M.Sc., Assoc. I. A. R. I. (with effect from 21-1-1956).

Scheme for setting up of Seed Testing Station

Entomologist	Shri H. N. Batra, B.Sc. (Ag.), Assoc. I. A. R. I. (with effect from 8-12-1955).

Co-ordinated plant Virus Research Scheme

(a) *Simla Centre*

1. Assistant Virus Pathologist	Shri R. N. Azad, B.Sc. (Ag.), Assoc. I. A. R. I.

(b) *Poona Centre*

1. Virus Entomologist	Shri P. M. Verma, M.Sc.
2. Virus Pathologist	Shri S. P. Kapoor, M.Sc., Ph.D.

(c) *Eastern Zone Kalimpong*

1. Virus Pathologist	Dr. S. P. Raychaudhuri, M.Sc., D. Phil. (Cal.), FLS., Assoc. IARI (with effect from 17-11-1955).

Co-ordinated Scheme for Plant Virus Diseases

(a) *Delhi Centre*

1. Assistant Virus Pathologist	Shri T. K. Nariani, B.Sc., Assoc. I. A. R. I. (with effect from 17-11-1955).

APPENDIX I—*contd.*

Gazetted staff of the Indian Agricultural Research Institute during 1955-56

SCHEME FOR THE USE OF ATOMIC ENERGY IN PLANT PATHOLOGICAL RESEARCH

1. Plant Pathologist	Dr. M. R. S. Iyengar, M.Sc., Ph.D. (with effect from 17-11-1955).
2. Assistant Plant Pathologist	Shri L. S. Bisht, M.Sc. (with effect from 1-6-1956).

SCHEME FOR THE STUDY OF BACTERIAL PLANT PATHOGENS

1. Plant Bacteriologist	Dr. M. K. Hingorani, B.Sc., Ph.D., Assoc. I. A. R. I. (with effect from 17-11-1955).

COORDINATED SCHEME OF SIMPLE FERTILIZER TRIAL IN CULTIVATOR'S FIELDS & MODEL AGRONOMIC EXPERIMENTS

1. Assistant Agronomist (T.C.M.)	Dr. K. S. Yawalkar (B.Sc. (Agri.), Assoc. I. A. R. I., Ph.D. (Mich.)

CENTRAL COLLEGE OF AGRICULTURE

1. Principal	Dr. T. J. Mirchandani, M.Sc., Ph.D. (Lond.), A. I. I. Sc. upto 29-7-1955. Dr. E. S. Narayanan, M.A., Ph.D. (Lond.), DIC., F.R.E.S., FESI (from 7-9-1955).
2. Lecturer in Agriculture	Shri K. P. Misra, M.Sc. (Ag.) (with effect from 10-9-1955)
3. Lecturer in Chemistry	Dr. W. V. B. Sundara Rao, B.Sc. (Hons.), Ph.D., Assoc., I. A. R. I.
4. Lecturer in Entomology	Vacant.
5. Lecturer in Physics	Dr. K. Y. Kathavate, M.Sc., Ph.D.
6. Lecturer in Agril. Engg.	Shri J. R. Badola, B. Sc. (Agril. Engg.) on other duty with effect from 31-5-1956. Since then the post is vacant.
7. Lecturer in Vety. Science	Dr. Gian Singh, L. V. P. (Hons.), P. G. (Mukteswar).
8. Lecturer in Horticulture	Dr. G. S. Randhawa, M.Sc., M. S. A., Ph.D. (Toronto), Ph.D. (Mich.).
9. Lecturer in Mycology	Dr. D. Suryanarayana, M.Sc., Ph.D.
10. Lecturer in English	Shri S. L. Vachhar, B.A. Hons. (Econ.), M.A.
11. Lecturer in Economics	Shri A. S. Kahlon, M.A.
12. Lecturer in Botany	Shri B. S. Fozdar, M.Sc.

I. A. R. I. DISPENSARY

1. Civil Assistant Surgeon	Dr. R. L. Handa.

APPENDIX II

TRAINING OF STUDENTS AND RESEARCH WORKERS

(a) *List of students awarded Post-Graduate Diploma.*

Name of students	Thesis
	AGRICULTURE
1. A. Venkatachari	Studies on the effect of nitrogenous and phosphatic fertilizers and their placement on different varieties of linseed.
2. A. K. Verma	Effect of different levels of inorganic fertilizers, nitrogen, phosphorus and potash, alone and in combination, on two varieties of wheat.
3. K. P. Mitra	Effect of organic manures, farm yard manure and castor cake, and inorganic fertilizers, NP, NPK, on wheat in cereal and legume rotation.
4. S. D. Verma	Effect of organic manures, farm yard manure, castor cake and green manure and inorganic fertilizers N, P, NP and NPK alone and in combination on wheat.
5. K. D. Puri	The differential response of sugarcane varieties to manurial treatments.
6. C. L. Wadhwa	Study of the relative effect of legume and fallow on the succeeding maize and wheat in different rotation.
7. Y. Joga Rao	Studies on different manurial treatments on the different varieties of *Nicotiana rustica*.
8. B. B. Turkhede	Differential response of different wheat varieties to varying levels of nitrogen and phosphate.
9. P. K. Bose	Studies on the mode of application of phosphate fertilizers on the yield of wheat.
10. B. L. Neema	Relative response of wheat varieties to different nitrogenous and irrigational doses.
11. S. V. Bokde	The relative efficiency of various commercial nitrogenous fertilizers in different doses and their time of application to wheat, N. P. 718.

APPENDIX II—*contd.*

TRAINING OF STUDENTS AND RESEARCH WORKERS

(*a*) *List of students awarded Post-Graduate Diploma*—contd.

Name of students	Thesis
	AGRICULTURE
12. S. K. Rana	Investigation on the effect of weedicides, nitrogen forms and doses on the yield of sugarcane.
13. C. R. Sharma	Effect of variation in depth of cultivation with different proportions of fertilizers and their method of application on the yield of potato.
14. S. L. Pandey	Effect of *guar* (cluster-bean) as green manure with phosphate and micro nutrients on wheat.
15. Swaroop Singh	Effect of different doses of farm yard manure and ammonium sulphate alone and in combinations on wheat in fallow-wheat and *bajra*-wheat rotation.
16. N. Pattanayak	The effect of irrigation *cum*-manurial-*cum*-cultivation practices.
	BOTANY
17. Amarjit Singh	The classification, evaluation and utilisation of breeding and agronomic characters in Cowpea and some of its related species.
18. N. L. Bhale	Studies on hybrid vigour in intervarietal crosses in *Gossypium hirsutum*.
19. D. S. Borgaonkar	Cytogenetical study of interspecific hybrids in *Triticum*.
20. S. N. Dubey	Genetical studies in *indica-japonica* hybrids in paddy (*Oryza sativa*).
21. K. B. L. Jain	Selection of wheat varieties suitable for cultivation under different agronomic treatments.
22. Joginder Singh	Studies on the combining ability of inbred lines in maize.
23. C. N. Mahadik	Study of genetic variability in linseed.
24. K. N. Mallanna	Study of the inheritance of reaction to rust in wheat.

APPENDIX II—*contd.*

TRAINING OF STUDENTS AND RESEARCH WORKERS

(*a*) *List of students awarded Post-Graduate Diploma*—contd.

Name of students	Thesis
	BOTANY
25. B. H. Mattai	A comparative study of the anatomy and other plant characters of three diploid strains and corresponding autotetraploids of rice.
26. K. N. Murty	Study of lodging and related characters.
27. A. T. Natarajan	(*a*) Study of the effect of some chemical mutagens on chromosomes. (*b*) Study of the chromosome behaviour of the F_1 of the crosses involving two chromosomal biotypes of *T. dicoccum*.
28. A. M. Pradhanang	Study of the variability of cultivated wheats of India II. Wheats of U. P. and Delhi States.
29. A. D. Saini	A study of some plant characters in relation to drought resistance in wheat.
30. S. S. Shah	Morphological and anatomical studies in the genus *Oryza*.
31. T. Y. Thorat	Study of the genetic variability in pigeon pea.
	SOIL SCIENCE AND AGRICULTURAL CHEMISTRY
32. D. A. Shinde	Chemical composition of wheat plants for assessing the manurial requirements of wheat crop in Delhi soil.
33. K. Rajagopalan	Effect of continuous application of fertilizers and manures on the carbon and nitrogen status of plants and soils and their microbiological activities.
34. D. V. Bhalkar	Nature of some typical saline and alkaline soil profiles in Northern India.
35. O. P. Dhamija	Iron and manganese relationship in some typical paddy and acid soil profiles.
36. M. S. Khera	Studies on the potassium status of Indian soils.
37. P. K. Thomas	Studies on laterites and lateritic soils of Malabar.
38. G. C. Padoley	Study of black soils of Madhya Pradesh developed under different parent materials.
39. C. M. Mathur	Study of Kotah soils (Rajasthan) to examine their suitability for irrigation.
40. G. Ramachandra	Nitrogen metabolism in berseem as affected by phosphatic fertilizers.

APPENDIX II—*contd.*

Training of students and Research Workers

(*a*) *List of students awarded Post-Graduate Diploma*—contd.

ENTOMOLOGY

41. Baldev Prasad	Studies on some Indian species of Orthoptera on the basis of male genitalia.
42. M. Ramachandra Rao	Longevity and rate of reproduction in *Trichogramma evanescens minutum* Riley, an egg parasite of the stem and root borers of sugarcane with various sugars and polyhydric alcohols.
43. T. S. Thontadarya	Effect of temperature and humidity on the rate of development of the immature stages and the longevity and fecundity of *Apanteles ancalei* Muesebeck (Braconidae : Hymenoptera) and endoparasite of pink boll worm of cotton, *Pectinophora (Platyedra) gossypiella* Saunders (Gelechidae : Lepidoptera).
44. P. N. Rana	The effect of temperature and humidity on the development and distribution of maize and *jowar* stem borer *Chilo zonellus* Swinhoe (Crambidae : Lepidoptera).
45. J. Gopalakrishna	Effect of temperature on insect susceptibility to fumigation.
46. G. C. Sharma	Comparative toxicity of some modern insecticides to the stored grain pest *Trogoderma granarium* Everts. (Dermestidae : Coleoptera).

MYCOLOGY AND PLANT PATHOLOGY

47. V. M. G. Nair	Studies on the genus *Phyllachora* in India.
48. Satynarayana Reddi	Comparative cultural, *Macrophima* and pathological studies on the *Macrophima* sp. and its mutant causing leaf spot of mango.
49. D. C. Sharma	Studies on the inhibition of potato virus X.
50. M. L. Narayana Sastry	Further studies on the properties of the antibiotic principle produced by *B. subtilis*.

APPENDIX II—*contd.*

Training of students and Research Workers

(*b*) *Students admitted during the year.*

Agronomy

1. A. B. Sharma.
2. A. K. Saha.
3. A. K. Sen Gupta.
4. B. K. Chatterjee.
5. B. M. Jhala.
6. C. R. Bisen.
7. C. R. K. Prasher.
8. D. K. A. Pholay.
9. H. C. Sikka.
10. J. B. Datey.
11. Jagdish Singh.
12. D. Devappa.
13. K. N. Sahay.
14. M. K. Misra.
15. M. L. Sethi.
16. N. J. Mudholkar.
17. O. P. Dhimole.
18. O. P. Gupta.
19. P. G. Shanware.

Agronomy

20. P. M. Jawade.
21. R. G. Barewar.
22. R. S. Misra.
23. R. T. Rawal.
24. S. C. Jethmalani.
25. T. M. Deshmukh.
26. S. K. Sharma.
27. V. Ramiah.
28. V. S. Deshmukh.

Botany

29. R. K. Bhattacharya.
30. K. N. Subramanyam.
31. P. K. Majumdar.
32. S. G. Pattack.
33. P. H. Rao.
34. B. K. Karibasappa.
35. N. P. Tiwari.
36. J. N. Sharma.
37. T. Venkataswamy.

APPENDIX II—*contd.*

TRAINING OF STUDENTS AND RESEARCH WORKERS

(b) Students admitted during the year — contd.

Botany

38. N. P. Mehta.
39. V. L. Chopra.
40. K. Sankaranarayan.
41. B. S. Ahluwalia.
42. B. B. Dey.
43. L. S. Hooroo.
44. H. R. Dave.
45. K. K. Jha.
46. M. R. Wanjari.
47. K. C. Dabral.
48. M. R. H. Quareshi.

Chemistry

49. M. A. Ali.
50. P. V. Anantharaman.
51. D. C. Bisen.
52. C. M. Deoras.
53. H. C. Dewan.
54. N. G. Godse.
55. N. N. Goswami.

Geology

56. V. K. Gupta.
57. N. H. Heris.
58. V. R. Kumar.
59. G. P. Misra.
60. K. K. Prasad.
61. Y. N. Rao.
62. D. K. Singh.
63. O. P. Mithal.
64. H. P. Singh.
65. K. Shankar.
66. J. L. Shinde.
67. L. L. Srivastava.
68. V. K. Mutatkar.
69. B. Behra.
70. M. G. Gupta.

Entomology

71. B. K. Bera.
72. S. S. Kumar.
73. Ajai Man Singh.

APPENDIX II—*contd.*

TRAINING OF STUDENTS AND RESEARCH WORKERS

(*b*) *Students admitted during the year*—contd.

Entomology

74. S. K. Sharma.
75. S. A. Joshi.
76. Narayana Shi.
77. K. D. S. Kathuria.
78. P. M. Nigam.
79. S. J. Das.
80. J. G. Pawar.

Mycology and Plant Pathology

81. K. V. Pingalev.
82. M. L. Sahni.

Mycology and Plant Pathology

83. M. M. Tiwari.
84. K. S. M. Sastry.
85. Pritam Singh.
86. Sushil Kumar.
87. R. C. Reddy.
88. K. Rajagopalan.
89. K. S. Dhanraj.

Plant Protection Course

90. V. N. Nigam.

(*c*) *Students admitted for short course training during the year.*

Chemistry

1. Vageeschandra.
2. B. B. Maharathy.
3. B. Rath.
4. S. K. Wadhawan.
5. S. B. Ranade.
6. D. Subbha Rao.

Mycology

7. C. Srinivasan.
8. K. Pantiah.

Mycology

9. D. C. Lucksom.
10. K. B. Joshi.
11. Inderjit Singh.
12. C. B. Tiwari.
13. R. K. Mukherji.
14. Mahabir Singh.
15. S. C. Banerjee.

(*d*) *Honorary Research Workers.*

Botany

1. M. P. Singh.
2. Thambi Ninan.
3. S. Bhaskar.

Chemistry

4. S. P. Bahl.
5. A. S. Desai.

Chemistry

6. K. B. Mistri.
7. M. N. Sadaphal.
8. Manmohan Singh.
9. P. S. Phadauri.
10. Kumari Shakuntala.

APPENDIX III.

List of publications during 1955-56.

1. Acharya, C. N. and Jain, S. P. — Influence of the method of storage on the microbiological properties of soil samples. *J. Ind. Soc. Soil. Sci.* **3**, 91.

2. Acharya, C. N. — Your home needs a gas plant. *Indian Farming*, **6**, 27.

3. Acharya, C. N. and Rajagopalan, K. — Effect of continuous application of manures and fertilizers on the carbon and nitrogen levels of the soils. *J. Ind. Soc. Soil. Sci.* **4**.

4. Ahuja, M. R. — Chromosome numbers of some plants. *Indian J. Genet. Pl. Breed.*, **15** : 142-43.

5. Ahuja, Y. R. — Effect of environment on the growth of embryo in autotetraploids of *toria*. *Curr. Sci.*, **24** : 205-06.

6. Asana, R. D. ; Mani, V. S. ; Pillay, K. P. and Gahlot, K. N. S. — Analysis of drought resistance in crop plants. I. The influence of soil drought on the relation between yield and ear characters in wheat. (Pot-culture) *Indian J. Genet. Pl. Breed.*, 15 : 59-79.

7. Azad, R. N. — Mutation in *Cucumis* virus 2 C. *Indian Phytopathology*, Vol. **9**, No. 1, 1956.

8. Banerjee, R. M. ; Dhingra, P. K. and Das, N. B. — Effect of vitamin B_{12} and methionine on the biological value of pulse proteins. *Sci. and Cult.*, **21**, 384.

9. Batra, H. N. — Occurrence of the corn bug, *Eurygaster Maura* L. as a pest of wheat in Kulu Valley and Himachal Pradesh. *Ind. J. Ent.* **17(3)** : 390.

10. Batra, H. N. — A note entitled danger of *Dacus* (Leptosyde) *longistylus* Wield becoming a pest of Cucurbitaceous plants in India. *Ind. J. Ent.* **17(2)** : 278-79.

11. Batra, H. N. — 'AK' grasshopper, *Poeciliocerus pictus* (Fabr.) (Acrididae) as a pest of Papaya and some other plants in Delhi. *Ind. J. Ent.* **17(1)** : 132.

12. Chandnani, J. J. — Studies on the relative value of different phosphatic manuring. *Ind. J. Agric. Sci.*, Vol. XXV : 175-192, 1955.

13. Chandnani, J. J. — Studies on the cultivation of *Gossypium hirsutum* in Delhi tract. *Indian Cotton Growing Review*, Vol. X : 1-8, 1956.

14. Chandnani J. J. and Kavitkar, A. G. — Studies on the response curve of nitrogen on wheat *J. Ind. Soc. Soil Sci.* Vol. **3** : 123-137, 1955.

15. Chatterjee, S. M. — Relative resistance of some National Pusa varieties of wheat to *Trogoderma granaria* Everts. *Ind. J. Ent.* **17(1)** : 125-127.

APPENDIX III—*contd.*

List of publications during 1955-56—contd.

16. Chona, B. L.	A brief survey of sugarcane diseases in India. *Presidential Address, Plant Pathology Section, Proc. 9th Congress International Soc. Sug. Tech.*, 1956.
17. Chona, B. L. ; Girdhari Lal and Kapoor, J. N.	Occurrence of *Heterosporium* disease of Garden Nastartium in India. *Current Science*, 1956.
18. Chona, B. L., Girdhari Lall and Kapoor, J. N.	*Alternaria zinniae* Pape in India. *Current Science*, 1956.
19. Chona B. L. and Kapoor, J. N.	Occurrence of *Cercospora* leaf spot of *Carica papaya* L. in India. *Current Science*, 1956.
20. Chona, B. L. and Munjal, R. L.	Notes on Miscellaneous Indian Fungi II. *Indian Phytopathology*, Vol. **8**, No. 2, 1955.
21. Chona, B. L. and Munjal, R. L.	Notes on Miscellaneous Indian Fungi III. *Indian Phytopathology*, Vol. **9**, No. **1**, 1956.
22. Chona, B. L. ; Munjal, R. L. and Bajaj, B. S.	*Vasudevalla*, a new genus of Sphaeropsidales. *Indian Phytopathology*, Vol. **9**, No. 2, 1956.
23. Chona, B. L. ; Munjal, R. L. and Kapoor, J. N.	Notes on Miscellaneous Indian Fungi IV. *Indian Phytopathology*, Vol. **9**, No. 2, 1956.
24. Chona, B. L. and Seth, M. L.	*Aphis maydis* Fitch. as vector of sugarcane mosaic in India. *Indian J. agric. Science.*
25. Chona, B. L. and Suryanarayana, D.	The occurrence of *Sclerospora philippinensis* Weston on "Kans grass" (*Saccharum spontaneum* L.) in India. *Indian Phytopathology*, Vol. **8**, No. 2, 1955.
26. Dakshinamurti, C.	Ionic diffusion in soil. *Proc. nat. Acad., Sci. (India)*, **24**, 25.
27. Dhamija, O. P. ; Murti, R. S. and Raychaudhuri, S. P.	Oxidation reduction on Redox Potential of some paddy and acid soils. *Proc. 43rd Indian Sci. Congr. Pt. III, 28.*
28. Dhingra, P. K. and Das, N. B.	Effect of vitamin B_{12} on the nutritive value of pulses. *Proc. Soc. Biol. Chem. (India)*, **13**, *47.*
29. Gandhi, R. T.	New soyabeans for your farm. *Ind. Farming, Jan.*, 1956.
30. Gandhi R. T. and Dabadghao, P. M.	Hubam clover is a welcome newcomer. *Ind. Farming March*, 1956.
31. Ghosh, A. B. and Raychaudhuri, S. P.	Studies on the fertilizer value of ammonium chloride and ammonium sulphate nitrate. *Proc. 43rd Indian Sci. Cong. Pt. III*, **10**.
32. Ghosh, A. B. ; Raychaudhuri, S. P. and Bhure, N. D.	Ammonium chloride and ammonium sulphatenitrate as sources of nitrogen to paddy and wheat. *J. Indian Soc. Soil Sci.* **4**, 23.
33. Gupta, Y. P. and Das, N. B.	Thiamine content of pure strains of pulses. *Proc. 43rd Indian Sci. Cong. Part III*, **49**.
34. Gupta, Y. P. and Das, N. B.	Nutritive requirements of *Lactobacillus leichmanii. Proc. 43rd Indian Sci. Cong. Pt. III*, **50**.

APPENDIX III—*contd.*

List of publications during 1955-56—contd.

35. Gupta, Y. P. and Das, N. B.	The quality of wheat as affected by manures and fertilizers. II. Thiamine, riboflavin and niacin content. *J. Indian Soc. Soil Sci.* **4**, 125.
36. Hingorani, M. K. ; Mehta P. P. and Singh, Nirmaljit.	Bacterial brown rot of potatoes in India. *Indian Phytopathology*, Vol. **9** No. 1, 1956.
37. Hingorani, M. K. and Sharma, O. P.	Bacterial disease of mango. *Indian Phytopathology*, Vol. 9, No. 2, 1956.
38. Idnani, M. A. ; Acharya, C. N. and Ray-chaudhuri, S. P.	Buying the fertilizers. *Indian Farming*, **4**, No. **3**.
39. Idnani, M. A. and Chibber, R. K.	Utilization of seeds of wild leguminous plants and trees. *Ind. and Cult.* **21**, 598.
40. Iyengar, M. R. S. and Srivastava, D. N.	Relationship of nutrition to growth and sexual reproduction in *Lophotrichus ampalus* Benj. *Trans. British Mycological Society.*
41. Joshi, A. B.	Polyploidy and organic evolution. Bull. No. 7 : Symposium on Organic Evolution. *Nat. Inst. Sci. India*, pp. 216-21.
42. Joshi, A. B. and Howard, H. W.	Meiotic irregularities in hexaploid oats. IV. Hybrids between *Avena sativa* (spring and winter varieties), *A. fatua*, *A. sterilis*, *A. byzantina* and *A. nuda*. *J. agric. Sci.*, **46** : 183-90.
43. Joshi, L. M. and Kak, Dulari	Mutation in *Puccinia graminis tritici* (Pers.) Erikss and Heen., Physiologic Race 194. *Indian Phytopathology* Vol. **8**, No. 2, 1955.
44. Kartha, A. R. S. and Sethi, A. S.	Distribution of oil in different parts of the coconut kernel. *J. sci. indus. Res.* (*Indian*), **15B**, 105.
45. Khan, A. R.	Green manuring is an economically sound practice. *Indian Farming*, Feb., 1956.
46. Khan, A. R.	Studies on the relative response of wheat varieties to different nitrogenous and irrigational doses. *Proc. 43rd Session, Ind. Sci. Cong. Part III* (*Abs.*), 1956.
47. Khan, A. R. and Sharma, C. R.	Effect of variation in depth of cultivation with various doses and mode of application of fertilizers on the yield of potato. *Proc. 43rd Session, Ind. Sci. Cong. Part III* (*Abs.*), *1956*.
48. Malhan, P. R. and Kartha, A. R. S.	Influence of substituents on the anti-oxidation of some oleic acid derivatives. *J. sci. indus. Res.* (*Indian*), **14** *B* 673.
49. Malhan, P .R. and Kartha, A. R. S.	The maximum peroxide value of ants oxiding fats under different conditions. *J. sci. indus. Res.* (*India*) **15***B*, 326.
50. Mehta S. C. and Dakshinamurti, C.	A modified steam distillation chamber for the extraction of nicotine. *J. sci. indus. Res.* **14**B, 609.
51. Mehta, S. C. and Dakshinamurti, C.	Spectrographic analysis of soils in the copper are *Curr. Sci.* **24**, 409.

APPENDIX III—*contd.*

List of publications during 1955-56—contd.

52. Mehra, K. L.	Chromosome numbers in tribe Andropogoneae, Gramineae. *Indian J. Genet. Pl. Breed.*, **15** . 144.
53. Mirchandani, T. J. and Sen, S.	Crop rotations in India. *I. C. A. R. Review Series No. 12, 1956.*
54. Mookerjee, S. and Jotwani, M. G.	Morphology of the male genital structures of some Indian thysanoptera : their taxonomic importance. *Ind. J. Ent.* **17**(1) : 65-75
55. Murty, G. S.	Wheat varieties. *I. C. A. R. Res. Bull. No. 13.*
56. Narayanan, E. S. and Kundan Lal	Studies on Indian Ichneumonidae (Hymenoptera) Part IV subfamily Pimplinae tribe Ephialtini, *Ind. J. Ent.* **17**(2) : 147-154.
57. Narayanan, E. S. and Kundan Lal	Studies on Indian Ichneumonidae (Hymenoptera) subfamily Banchinae Part III tribe Banchini. *Proc. Ind. Acad. Sci.* **43**(1) : 207-12.
58. Narayanan, E. S. and Mookerjee, P. B.	Effect of nutrition on the longevity and rate of reproduction in *Trichogramma evanescens minutum* Riley (Chalcidoidea Hymenoptera) *Ind. J. Ent.* **17**(3) : 376-82.
59. Narayanan, E. S. and Subba Rao B. R.	The anatomy of the female reproductive system of *Microbracon gelechiae* Ashm. *Beitrage Zur Entomologie, Band 5 NR 3/4, pp. 1-8,* 286-293.
60. Narayanan, E. S. ; Subba Rao, B. R. and Thakre, K. R.	A note on the differences in the structure of mandibles in ecto-and endo-parasite larvae and their relationship with their hosts. *Ind. J. Ent.* **17**(3) 383-385.
61. Narayanan, R. and Kartha, A. R. S.	A tentative method for detection of hydrogenated oil in *ghee* by estimation of iso-oleic acid. *J. sci. indus. Res. (India)* **14**B, 544.
62. Nimgade, N. M.	Preliminary experiments on the effect of addition of gypsum and calcium chloride on percolation of saline soils. *Proc. 43rd Indian Sci. Cong. Pt. III,* **27**.
63. Nariani, T. K.	Leaf-curl of papaya. *Indian Phytopathology,* Vol. **9**, No. 2, 1956.
64. Padoley, G. C. and Tamhare, R. V.	Study of black soils of Madhya Pradesh with reference to their parent rocks. *Proc. 43rd Indian Sci. Cong. Pt. III,* 17.

APPENDIX III—*contd.*

List of publications during 1955-56—contd.

65. Pal, B. P. — N. P, 718 Indian Farming 6 : 7-9. (1956)

66. Pal, B. P. — The Rose Garden. Ind. Hort. 1 : 21-28. (1956)

67. Pal, B. P. — Agricultural Research in India. Ind. Agril., Industrial & Trade Review, Annual Andhra Education Society, Bombay : pp 119-123. (1956)

68. Pal, B. P. and Sikka, S. M. — Exploitation of hybrid vigour in the improvement of crop plants, fruits and vegetables. Indian J. Genet. & Pl. Br. 16 : pp 98-104. (1956)

69. Pradhan, S. and Bhatia, S. K. — The effect of temperature and humidity on the development of the sugarcane stem borer, *Chilotraea infuscatellus Snell. Internat. Soc. Sug. Tech. 9th Cong ; India, January, 1956.*

70. Pradhan, S. and Jotwani, M. G. — Bioassay of insecticides IV. Comparative toxicity of some important insecticides to *Utetheisa Pulchella* Linn (Arctiidae : Lepidoptera) *Ind. J. Ent.* **17**(3). 315-16.

71. Pradhan, S. and Prasad, S. K. — Correlation between the degree of damage due to *Chilo zonellus* Swin and the yield of *jowar* grain. *Ind. J. Ent.* **17**(1) : 136-37.

72. Pradhan, S. and Sharma, G. C. — Control of Khapra (*Trogoderma granarium* Everts) *Curr. Sci.* **25**(1) : 22.

73. Raheja, P. C. — Making the farmers fertilizer-minded. *Indian Farming, Vol. VI, No. 3, 65-67.*

74. Raheja, P. C. — Physiological research in relation to agronomy of sugarcane in India. *Internat. Soc. of Sugarcane Technologists 9th Cong. India, Jan.*, 1956.

75. Raheja, P. C. — Fertilizer use for better crops in the U. S. A. *Indian Farming, Dec. 1955.*

76. Raheja, P. C. — India's harvesting seasons. *The March of India, Vol. No. II, pp. 7-10.*

77. Raheja, P. C. and Misra, M. D. — Influence of nitrogen, phosphate, potash and calcium alone and in combination on wheat. *Indian J. agric. Sci. 1955, Vol. XXV, Part II (March) pp. 87-104.*

78. Rajan, S. S. — The effectiveness of the mass pedigree system of selection in the improvement of seed setting in autotetraploids of toria. *Indian J. Genet. Pl. Breed.*, **15** : 47 49.

79. Ramamurti, B. — The clay minerology of some soils of India. *Proc. 42nd Indian Sci. Cong. Pt. IV, 102.*

80. R. V. Ramiah — A new Chaff Cutter. *Indian Farming, April, 1956.*

81. Randhawa, G. S. — Citrus root stocks with special reference to disease resistance and compatibility. *Central Coll. Agric. Mag.*, **1** : 27-28.

82. Randhawa, G. S. — Introduction of fruit trees in India and development o the fruit industry. *Indian J. Hort.*, **12** : 201-03.

APPENDIX III—*contd.*

List of publications during 1955-56—contd.

83. Rattan Lal	Effect of the water content of aphids and their host plant on the appearance of alatae. *Ind. J. Ent.* 17(1) : 52-62.
84. Rattan Lal and E. Haque	Effect of nutrition under controlled conditions of temperature and humidity on longevity and fecundity of *Sphaerophoria scutellaria* (Fabr.) (Syrphidae : Diptera) Efficacy of its maggots on aphid predators. *Ind. J. Ent.* 17(3) : 317-25.
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86. Raychaudhuri, S. P.	Survey and classification of Indian soils. *Presidential Address, 43rd Indian Science Cong. pp. 1-16.*
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88. Raychaudhuri, S. P. and Nimgade, N. M.	Studies on saline soils of Delhi State. III. Dabar (low-lying) areas. *Indian J. agric. Sci.* **25**, 105.
89. Raychaudhuri, S. P. and Pathanian, P. S.	A mosaic disease of radish (*Raphanus sativus* L.). *Indian Phytopathology Vol.* **8**, No. 2, 1955.
90. Raychaudhuri, S. P.; Vyas, N. D.; Das, S.C. and Ghosh, A. B.	Salvaged ammonium nitrate as fertilizer. *Indian J. agric. Sci.* **25**, 193.
91. Sadaphal, M. N. and Das, N. B.	Effect of micro-element fertilizers on the yield and quality of wheat. *Proc. 43rd Indian Sci. Cong. Pt. III*, 47.
92. Satyanarayana, K. V. S.	Laterite of Kutch. *Proc. nat. Acad. Sci. (India)* **24**, 17.
93. Satyanarayana, K. V. S. and Narasimha Rao, C.	Geology of Little Rann of Kutch and its Bets. *J. Ind. Soc. Soil Sci.* **3**, *87.*
94. Satyanarayana, K. V. S. and Thomas, P. K.	Influence of parent materials on the mineralogical composition of laterite. *Proc. 43rd Indian Sci. Cong. Pt. III*, *25.*
95. Sen, A.	Comparative studies on absorption and retention of nitrogen from ammonium sulphate and ammonium chloride by Indian soils. *J. Indian Soc. Soil Sci.* **4**, *49.*
96. Sen, A.	Nitrogen fixation by algal associations in tank silts. *Indian J. agric. Sci.* **26**, *89.*

APPENDIX III—*contd.*

List of publications during 1955-56—contd.

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98. Sen, S. and Choubey, S. D. — Effect of nitrogen and phosphorus on the yield and quality of barley varieties with special reference to correlation and regression studies. *Jubulpore agric. Coll. Mag.*, **1** : *14-26, 1955-56.*

99. Sen, S. and Joshi, M. G. — Inheritance of resistance to black rust in wheat. *Indian J. Genet. Pl. Breed.*, **15** : 36-46.

100. Sen, S. and Kavitkar, A. G. — Pusa Permanent Manurial Experiment (New Series). Studies on the maize yields in relation to the preceding crops in the rotation. *J. Indian Soc. Soil Sci.* **3** : *117-121, 1955.*

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104. Sethi, A. S. and Kartha, A. R. S. — Direct determination of saturated acids in small quantities of fats and mixed fatty acids. *J. sci. indus. Res. (India)*, **15B**, *103.*

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109. Singh, H. B. and Bhagchandani, P. M. — Onions that yield well and store well. *Indian Fmg*, **5**(8) : 24-26.

APPENDIX III—*contd.*

List of publications during 1955-56—contd.

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111. Singh, H. B. and Sikka, S. M. — Pusa recommends two *Luffa* gourds. *Indian Fmg*, 5(5) : 25-27.

112. Singh, Rattan ; Biswas, T. D. and Das, N. B. — Detection of free nicotinic acid in cereals by paper chromatography. *Proc. Soc. biol. Chem.* (*India*) **13**, 38.

113. Subba Rao, B. R. — *Microbracon chinensis* Szepher, A short note on the technique of its mass multiplication. *Ind. J. Ent.* **17**(3) : 387-89.

114. Swaminathan, M. S. — Overcoming cross-incompatibility in some Mexican diploid species of *Solanum*. *Nature* (*Lond.*) **176** : 887-88.

115. Swaminathan, M. S. — The origin of the early European potato—evidence from Indian varieties. *Proc. 43rd Indian Sci. Congr.*, Agra, Pt. IV.

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